

STRUCTURAL FAILURES

HEARINGS
BEFORE THE
SUBCOMMITTEE ON
INVESTIGATIONS AND OVERSIGHT
OF THE
COMMITTEE ON
SCIENCE AND TECHNOLOGY
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STRUCTURAL FAILURES

TUESDAY, AUGUST 3, 1982

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT,
Washington, D.C.

The subcommittee met, pursuant to call, at 9:35 a.m., in room 2325, Rayburn House Office Building, Hon. Albert Gore, Jr. (chairman of the subcommittee) presiding.

[The opening prepared statement of Mr. Gore follows:]

OPENING STATEMENT OF HON. ALBERT GORE, JR., CHAIRMAN, SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT, AUGUST 3, 1982

The Subcommittee meets today and tomorrow to hear testimony about the probable causes of failures in public structures. Failures such as the collapse of the pedestrian walkway in the Hyatt Regency in Kansas City last year, and the collapse of the Hartford Civic Center roof in Connecticut some years ago are well known. Other failures, such as that illustrated by the need to strengthen, after it was opened, the horizontal trusses on the \$16 million Field House built for the Lake Placid Olympics are not as well known.

Are these illustrations, and similar dam, bridge and building failures of recent years coincidental or is there a generic cause—a common failure in design research, technology or techniques or in the training of our engineers. One year ago, the Subcommittee undertook an examination of the engineering industry to seek an answer to this question. During the past year, the staff conducted interviews with a select group of engineers. Today and tomorrow we will examine some of the preliminary conclusions. The data base will be expanded by a broader survey that will be completed later in the fall.

We are not here to investigate the cause of any particular failure or to place blame on any part of the construction industry. Rather, our purpose today and tomorrow will be to obtain a better understanding of the actions that either take place, or fail to take place, during the course of a building project which eventually results in failure. If we can do that, we may be able to determine measures which could help reduce the number of these occurrences.

From the Subcommittee survey, there appear to be several basic problems in the conduct of the construction industry which can ultimately result in structural failures. A summary of the 15 preliminary findings from the subcommittee's interviews will, without objection, be placed in the record. The major preliminary findings are:

1. The construction industry is unique. It differs from a manufacturing venture, in that a new organization consisting of architect, engineer, builder, owner, insurer, and subcontractors join for the first time to construct a new facility. The organization itself has no time to mature and establish efficient lines of communication.
2. There was little evidence of consistent methods for maintaining overall project quality control starting with design and continuing through completion of construction. In summary, no single firm or person appears responsible for overall project quality control on many projects.
3. The professional structural engineer who is responsible for the project design does not perform all of the design work. In fact, one of the most important parts of the design, certain connection details, are frequently done by steel or precast concrete fabricators.
4. The structural design engineer is the only person who could reasonably inspect the structural work as it is constructed and be able to detect a potential failure. It

appears typical in today's construction industry to discourage the design engineer from inspecting the work in the field.

5. Recent engineering college graduates are perceived as being better mathematicians and especially adept at using computers for structural design than were graduates of even 5 years ago. However, they are perceived to lack appreciation for the overall behavior of complete structures under all environmental conditions.

6. Long span structures such as those used for bridges and sports arenas, require more exacting quality control during design and construction than do short span structures. There may be a need to develop new approaches to design which emphasize analysis of dynamic behavior.

While we do not see a primary role for the Federal Government in legislating quality control, we want to consider if there is a more effective way for the construction industry to improve quality control and engineering design. As land commands more and more of a premium, the need to build higher and longer will increase. We, therefore, also want to explore whether a federal organization, such as the National Transportation Safety Board, which investigates transportation accidents, would be a cost-effective way to identify causes of failures and help to promote safer technology and design.

Today we will hear from three representatives of professional associations involved in the construction industry, and two federal agency representatives. We welcome you and look forward to hearing your testimony.

Mr. GORE. The subcommittee will come to order. I would like to welcome all of our witnesses and our guests.

The subcommittee meets today and tomorrow to hear testimony about the probable causes of failures in public structures. There have been a large number of such failures in the last few years.

Failures, such as the collapse of the pedestrian walkway in the Hyatt Regency in Kansas City last year, and the collapse of the Hartford Civic Center roof in Connecticut some years ago, are well known.

Other failures, such as that illustrated by the need to strengthen, after it was opened, the horizontal trusses on the \$16 million field house built for the Lake Placid Olympics are not as well known.

Are these illustrations, and similar dam, bridge, and building failures of recent years coincidental, or is there a generic cause—a common failure in design research, technology or techniques, or in the training of our engineers?

One year ago, the subcommittee undertook an examination of the engineering industry to seek an answer to this question. During the past year, the staff conducted interviews with a select group of engineers. Today and tomorrow, we will examine some of the preliminary conclusions. The data base will be expanded by a broader survey that will be completed later this fall.

We are not here to investigate the cause of any particular failure or to place blame on any part of the construction industry. Rather, our purpose today and tomorrow will be to obtain a better understanding of the actions that either take place, or fail to take place, during the course of a building project which eventually results in failure. If we can do that, we may be able to determine measures which could help reduce the number of these occurrences.

From the subcommittee survey, there appear to be several basic problems in the conduct of the construction industry which can ultimately result in structural failures. The major preliminary findings are:

First, the construction industry is unique. It differs from a manufacturing venture, in that a new organization consisting of architect, engineer, builder, owner, insurer, and subcontractors join to-

gether for the first time to construct a new facility. This new organization, itself, has no time to mature and establish efficient lines of communication.

Second, there was little evidence of consistent methods for maintaining overall project quality control starting with design and continuing through completion of construction. In summary, no single firm or person appears responsible for overall project quality control on many projects. This is very disturbing.

Third, the professional structural engineer who is responsible for the project design does not perform all of the design work. In fact, one of the most important parts of the design, certain connection details, are frequently done by steel or precast concrete fabricators.

Fourth, the structural design engineer is the only person who could reasonably inspect the structural work as it is constructed and be able to detect a potential failure. It appears typical in today's construction industry to discourage the design engineer from inspecting the work in the field.

Fifth, recent engineering college graduates are perceived as being better mathematicians and especially adept at using computers for structural design than were graduates of even 5 years ago. However, they are perceived within the profession to lack appreciation for the overall behavior of complete structures under all environmental conditions.

Sixth, long-span structures such as those used for bridges and sports arenas, require more exacting quality control during design and construction than do short-span structures. There may be a need to develop new approaches to design which emphasize the analysis of dynamic behavior.

Now, while we do not see a primary role for the Federal Government in legislating quality control, we want to consider if there is a more effective way for the construction industry to improve quality control and engineering design. As land commands more and more of a premium, the need to build higher and longer will naturally increase.

We, therefore, also want to explore whether a Federal organization, such as the National Transportation Safety Board, which investigates transportation accidents, would be a cost-effective way to identify causes of failures and help to promote safer technology and design.

Today, we will hear from three representatives of professional associations involved in the construction industry, and two Federal agency representatives. We welcome you and look forward to hearing your testimony.

Without objection, the prepared remarks of the ranking minority member, Mr. Walker, will be included in the record in full at this point, and the remarks of the ranking member of the full committee, Mr. Winn, will be included, as well. He has a particular interest in this set of hearings.

[The prepared statements of Mr. Walker and Mr. Winn follow:]

OPENING REMARKS OF REPRESENTATIVE ROBERT S. WALKER

Mr. Chairman, our hearings, which start this morning, are of importance to the Committee and to the American public not because there would appear to be a legislative answer to the problem of structural failures, but because it is obvious to me, and to many other Members of the Congress, that structural failures have already become a national problem which can endanger the lives of many citizens, at any time, and in any location.

Despite the fact that we seem to see more and more television coverage of disasters caused by structural failures it is not necessarily true that these failures are occurring more frequently than in the past. America is in the midst of a building boom which is unequalled in our history. One merely has to look around the city of Washington to realize the entire face of the city has changed dramatically in the last fifteen years. That is also true in many other cities across the land.

But, even if the number of failures relative to the number of new starts has not increased, it is disturbing that there are so many in any case. A partial list of structural failures which was developed by the staff goes on for four pages and lists problems which range from the collapse of roofs in public buildings to the failure of dams and serious structural failures on bridges on our interstates. I ask that the list appear in the record.

All of these are enough to cause major concern within the Congress. The public has a right to expect that facilities which are designed for public use, and which are often funded with the public's funds, should be safe for public use.

It is apparent that expectation is not being realized. But, what may be more important in the immediate future, is the fact that the federal government may be less able to jump in and either serve as a Federal watchdog over projects, or provide funds to correct problems as they become identified.

We are not only in a time of very tight federal funding, but we are also currently facing a major crisis in finding ways to address the problem of a decaying America. Our systems of roads, bridges, railroads, and sewers are rapidly nearing the point of final collapse. The current issue of Newsweek has a cover story on this problem which says that the total cost of needed repairs to such public facilities could run as high as \$3 trillion.

What I hope to see these hearings result in is a better understanding of the magnitude of the problems facing the nation here on Capitol Hill, and perhaps, a cooperative relationship developing among the Congress, the National Academy, and the engineering and architectural professions. It may be that such cooperation might lead to better understanding and eventually the development of a model Federal code which would lead to better designs, and less failures.

Thank you Mr. Chairman.

OPENING STATEMENT OF THE
HONORABLE LARRY WINN, JR. (R-KAN.)
HEARING ON STRUCTURAL FAILURES
AUGUST 3, 1982

THANK YOU, MR. CHAIRMAN. I AM PLEASED TO BE HERE THIS MORNING.

I HAVE A PERSONAL INTEREST IN THESE HEARINGS, NOT ONLY BECAUSE OF THE WELL KNOWN TRAGEDY THAT OCCURRED IN KANSAS CITY, BUT BECAUSE OF MY OWN EXPERIENCES IN THE CONSTRUCTION INDUSTRY.

HOPEFULLY, WE WILL APPLY WHAT WE HAVE LEARNED TO FUTURE PROJECTS IN AN EFFORT TO SHARPLY REDUCE, IF NOT ELIMINATE, FUTURE STRUCTURAL FAILURES. I HOPE THESE HEARINGS WILL SHED SOME LIGHT ON WHAT NEEDS TO BE DONE IN THE INDUSTRY.

WE IN THE FEDERAL GOVERNMENT CANNOT LEGISLATE THE ELIMINATION OF STRUCTURAL FAILURES, BUT HOPEFULLY WE CAN TRANSFUSE SOME OF WHAT WE HAVE LEARNED FROM OTHER INDUSTRIES LIKE AEROSPACE TO CONSTRUCTION IF AND WHERE SUCH TRANSFERS MAKE SENSE.

THANK YOU, MR. CHAIRMAN.

Mr. GORE. Our first panel consists of Jerome Cooper, representing the American Institute of Architects here in Washington; Mr. Harold R. Sandberg, president of the Alfred Benesch Co. in Chicago. He is representing the American Consulting Engineers Council; and Dr. Richard N. Wright, director of the Center for Building Technology, accompanied by Dr. Edward Pfrang, Chief of the Structures Division, with the National Bureau of Standards.

Gentlemen, welcome to you. We certainly appreciate your help in this inquiry and, without objection, your prepared remarks will be put in the record in full, and if you care to summarize any portions of your statement, that will be fine with us.

Before we begin, let me recognize the ranking minority member of the full committee, Mr. Winn.

Mr. WINN. Thank you, Mr. Chairman. I appreciate the opportunity to listen to the panel this morning, and I know you have scheduled 2 very important days of testimony, and I have a personal interest in these hearings, not only because of the well-known tragedy that occurred in Kansas City, but because of my own experiences in the construction industry. Hopefully, we will apply what we have learned to future projects in an effort to sharply reduce, if not eliminate, future structural failures.

I hope these hearings will shed some light on what needs to be done in the industry. We, in the Federal Government, cannot legislate the elimination of structural failures, but hopefully we can transfuse some of what we have learned from other industries, like aerospace, into construction if and where such transfers make any sense. And, Mr. Chairman, I am looking forward to the testimony of these expert witnesses.

Thank you very much.

Mr. GORE. Well, thank you.

Without further ado, we will invite Mr. Cooper, representing the American Institute of Architects, to be our leadoff witness. Welcome. Please proceed.

STATEMENTS OF JEROME M. COOPER, REPRESENTATIVE, AMERICAN INSTITUTE OF ARCHITECTS; HAROLD R. SANDBERG, PRESIDENT, ALFRED BENESCH & CO., CHICAGO, ILL., REPRESENTING THE AMERICAN CONSULTING ENGINEERS COUNCIL; AND RICHARD N. WRIGHT, DIRECTOR, CENTER FOR BUILDING TECHNOLOGY, ACCOMPANIED BY EDWARD O. PFRANG, CHIEF STRUCTURES DIVISION, NATIONAL BUREAU OF STANDARDS

Mr. COOPER. Thank you, Mr. Chairman.

My name is Jerome Cooper, FAIA. I appear today on behalf of the American Institute of Architects, the association representing the architectural profession.

I am president of the Atlanta architectural firm of Cooper Carry & Associates, Inc., a firm active in the design of many types of public facilities, including educational, commercial, multifamily housing, health care, and detention facilities.

As a former member of the AIA board of directors and the institute's long-span building panel, I greatly appreciate this opportunity to appear before the committee today and to contribute to these 2 days of valuable hearings.

The AIA supports the committee's efforts in examining the underlying causes of structural failures in public facilities during the last 6 years and offers its extensive resources toward improving the structural integrity of the built environment. By widening the scope of the committee's investigation beyond particular failures, it greatly increases the usefulness and importance of its findings to the construction industry and the public at large.

While public attention on building failures has clearly been heightened during recent years, buildings have collapsed since mankind first began to build. General reasons for these failures may include a wide range of factors and how they interface.

To begin an examination of areas that possibly contribute to structural failures, one must scrutinize the factors such as technical, legal, materials, management, contracting, economic, organization, procedures, financial, and quality control methods.

Simply put, collapse occurs because materials deteriorate, because buildings are struck by wind, earthquakes, snow, floods, or other natural phenomena; because of overloads, fires and explosions; because of lack of maintenance or improper use; and because of errors in design or construction.

On occasion, a specific circumstance may provoke a collapse. It is not often, however, that one can attribute an entire collapse to a single cause. Buildings deteriorate. Occupancy requirements shift. So do loadings, exit, and fireproofing requirements and energy requirements. The resulting characteristics of continuous change in buildings places special demands upon the owner, architect, engineer, contractor, inspection agency, and maintenance personnel.

Much of this can be said of any structure. But because of the far-reaching consequences—including major threats to life and property—a collapse is of special concern when it happens to a large public arena. Auditoriums, sports stadiums, gymnasiums, theaters, large places of worship, airplane hangars—are buildings which may shelter tens of thousands of people at any one time and represent tens of millions of dollars in capital investment.

Mr. Chairman, I draw better than I speak.

Mr. GORE. You speak fine. Our microphone system is perhaps not the best in the world, and we wanted to get it a little closer to you.

Mr. COOPER. Perhaps of most importance is the confidence and psychological well-being which must be guaranteed our citizens by the integrity of the structures they inhabit. Ail of these considerations demand continued attention and improvement by those of us in the construction industry as we serve the esthetic and infrastructure needs of the Nation.

The AIA believes that many factors are involved in the structural integrity of a building. Before specific reasons for structural failure are examined, it is important to understand the architects' role, the process of design and how it relates to construction quality.

Even in the most conventional of buildings, the design, construction and occupancy phases of a project's development are interrelated. Accordingly, a strong process control system should be implemented. Such a system traditionally usually involves four basic interests: the owner's, the design professional's, the general contractor's, and the operator of the facility. These parties coalesce to

form the building team, each with delineated responsibilities to the other and the public.

Newer types of construction team organization have led to non-traditional relationships among team members. This can create a difference in emphasis on some portions of the project, and may modify the team members' responsibilities to each other.

For example, construction management and design/build types of team organization tend to stress tighter construction schedules and earlier determination of construction costs. Sometimes, this is done to the detriment of design innovation or of the thoroughness with which documents are prepared. Moreover, the rise of intermediaries, such as the construction manager or the design/build contractor, between the owner and the design professional team, could inhibit the free flow of information between them. As a result, their respective duties may, on occasion, become clouded.

If the owner is to select a team organization which best suits his goal of structural integrity, he should understand the strengths and weaknesses of each type of organization and the duties and responsibilities of each team member.

The design professionals on the building team should be led by a generalist—someone who has an overview of the project and a sense of the links among its various parts, and is aware of the context in which the project is to be built.

Controls aimed at securing a safe structure should begin as soon as the owner sets the parameters for his project, including the schedule, goals in building, budget, team organization.

The first phase is design. Design is not necessarily a logical, routine sequence even on conventional projects, let alone on buildings as complex as long-span structures. There is not a beginning and a logical conclusion. It is a process of shaping and reshaping.

During this shaping, changes take place. Problems can occur. As you have correctly surmised, there is a fragmentation in the design team. When you begin with the design and then you come back and pick up changes, you tend to lose threads.

The chance for this type of omission clearly exists for conventional buildings. Since such projects are ordinarily developed in self-contained phases, an orderly checking process should uncover this type of defect and remedy it in time.

In a construction management and a design/build framework, however, in which construction often begins before all construction documents have been prepared, checked, and coordinated, the opportunity for this type of omission is especially high. Because of the unique demands of a long-span building and the special links among its parts, this type of omission can lead to conditions that could become critical, and indeed have, on some occasions.

As a safeguard, some projects have involved design checks by third-party, independent engineers. Professional reactions to such design reviews have changed over the past few years from resistance to cooperation. At one time, there was a feeling in the profession that when someone was hired to check an architect's design because it created personal difficulties between the project team members. Now, the more common attitude today encourages review and quality control by third-party engineers.

Still, the project team is the best one to do the checking, and the existence of a design review process on a project neither relaxes the checking process by the original design team nor relieves that team of its responsibility.

Independent design reviews should not be mandatory but should result rather from professional judgment by the design team and by informed consent of the owner, because we are talking about additional costs to the owner.

Views among government bodies, such as city building departments, as to the degree of reviews and approvals they provide on project drawings and specifications varies widely. Some typically call for third-party design checks before issuing a building permit; others provide only perfunctory reviews. Even so, many owners and some architects and engineers tend to overrely on review of project documents by municipal or other building officials. This faith may stem from the false idea that when a building official reviews project drawings and specifications and issues a building permit, the result is some form of irrevocable approval, which transcends the requirements of the applicable building code.

In my experience, many owners really do believe that once they get a building permit, and that they have passed the first test.

The role of the design professional is clearly of major significance to the construction project team and the building's structural integrity. While many factors impact on the building's performance, including those already mentioned, I would like to now focus the committee's attention and our remarks to a number of problem areas. These include long-span structures, codes and standards, building failure documentation, procurement of A/E services, and design professional liability. In addition to my written and oral remarks, I would like to submit for the hearing record documents useful to those concerned with the issue at hand.

In the past few years we have seen several collapses of long-span structures, as you outlined. The major difference between a long-span and short-span structure exists in the lack of redundancy of structural elements. Many long-span structures have fewer major structural elements. Hence, should one of these structural elements fail, there are fewer alternative paths of load resistance than would be found in most short-span structures. This means the load cannot be transformed down through the structure, as it can in short-span structures.

Another characteristic of such structures is that they generally house a large number of people at one time.

As a result of some of these collapses, the American Institute of Architects in the fall of 1979 convened a professional panel of prominent architects, engineers, and contractors, and asked them to review the procedures for the design and construction of buildings with large, column-free interior spaces, and then to develop recommended actions which could lead to a reduction in the element of risk.

The panel did no technical investigation of specific collapses, nor did it attempt to find fault or place blame. Since each construction project has unique requirements, the panel recognized that architects, engineers, contractors, and others involved with a project

must use proper professional judgment, apart from any specific conclusions contained in their report.

However, the panel's report—entered for the hearing record—does attempt to provide some guidance to design professionals for reducing the risk of collapse of long-span structures. The report recognizes that collapse of long-span structures can be attributed to three main categories: procedural conditions; technical conditions; and natural conditions.

Several other factors were brought out by the nature of long-span buildings. These included progressive collapse—where the failure of one structural member overloads another, causing further and sequential failure—and the special sensitivity of long-span designs to secondary stresses.

For the purposes of the report, secondary stresses were defined as those caused by deflection and the interaction of building elements. Various experts also pointed out these added secondary effects, such as expansion or contraction due to heat or cold, snow drifts, ponded water, air infiltration, vibrations, and general operation of the structure. Any or all of these influence the structure's capacity to remain standing.

Individually, none of these factors and conditions necessarily caused collapse, but they did show that long-span buildings are quite different from conventional, average-span structures. What, then, are the features that mark a long-span building? Identifying these features and showing how each influences design and construction are important first steps.

Lack of redundancy is one. Most short-span structures have alternative means of structural support. Many long-span structures, by contrast, have relatively fewer major structural elements, and fewer alternative paths of load resistance. This lack of redundancy makes the long-span structure more vulnerable to general collapse in case of accidental overload or member weakness. Long-span structural systems, according to testimony before the panel, "utilize the material in the structure to the maximum."

Upon conclusion of the long-span panel's work, the panel concluded that added study and development of design guideline materials were desirable. This would further improve the knowledge and procedures used by those involved in producing and using long-span buildings. Thereby helping to obviate previously encountered problems and contributing results of important national significance. The panel members consequently reached the following additional conclusions:

That existing knowledge should be correlated to produce the following:

One special series of guideline documents and practice aids to assist design practitioners in fulfilling the special requirements of long-span design and construction.

Two, project delivery management manual for long-span design and construction to cover all members of the building team, and including tasks, responsibilities, checks and alerts. Such a manual should be geared to traditional as well as newer delivery methods and should recognize the tradeoffs inherent in each of the methods.

That research is needed to uncover new or improved knowledge and practice tools. The panel believed such an effort could involve

institutions, professional societies, individual design professionals or their firms, as well as other groups such as construction contractors and standards-making bodies. Specific research objectives would include:

Develop comprehensive, coordinated building code requirements covering long-span design and construction.

Develop guidelines for progressive failure analysis investigations on long-span projects.

Develop recommendations relating design safety factors to anticipated levels of field control.

Develop practice materials which would create among designers greater awareness of the impact of secondary factors on the performance of the long-span structure.

Develop guidelines for design review of the architect's and engineer's structural design and calculations.

Develop guidelines dealing with field and with laboratory testing of long-span structural components and connections. During the long-span study, we learned that there are no basic standards for criteria of how often a bolted structure should be tested. There are also no basic standards for how often one should take soil tests underlying a structure. It generally is left up to the design professionals involved in that project. The task force thought that some guidelines would be useful there. Mr. Chairman, I do not mean to say that the type of tests are not defined, but the number of times they that should be utilized are not defined.

Develop recommended course materials for use by architecture and engineering schools stressing the special and procedural aspects appropriate to long-span buildings.

Produce guidelines for developing documents for erection procedure requirements for long-span projects.

A critical element in any discussion of structural integrity is the codes and standards process. Codes are developed in the public interest by States, cities, and private model code-writing groups.

The model codes are designed to be adopted basically as written, possibly with minor variations, or to be used as a basis for local or State-adopted codes. The model code development system has helped to bring about more uniformity in codes. Despite the efforts of the model code groups, the building regulatory system in the United States remains a patchwork of ad hoc regulatory processes which is in need of coordination and uniformity.

It would take a lawyer to know which codes apply in my city. It would take a lawyer, Mr. Chairman, to know which codes apply in your city, not an architect. It can be a full-time job researching them, staying abreast of them and being aware of the changes.

In addition to that, I would like to report that the panel found that several of the codes were unnecessarily and vague in many of the requirements; that they permitted no specific relationship to no-drift criteria, of geographical mapping of local conditions in snowdrifts in cold country and in live load reductions that are permitted as a result of that as well as the effects of building operation on live load reductions.

Specifically, if a building is to be heated at all times, and it is a long span structure, then the engineer is permitted these certain assumptions.

If, on the other hand, as a result of the energy crisis or energy considerations the operator determines that the building will not be heated and that is not part of the design program, the building could incur secondary stresses that can be substantial.

A systematic understanding of past building failures would go a long way to prevent past mistakes from being repeated. However, up to now, there has been no central archive on the causes of building failures or systematic analysis of the Nation's building failures, similar to the Swiss study of 800 building failures over a 16-year time period.

The reasons for this lack of documentation research are many. First, many materials and subsystem failures go unnoticed or undocumented in the building trade or the popular press. Second, court proceedings and years of protracted litigation frequently prevent information on probable causes from being released to the general public and the design community.

Mr. Chairman, I will skip my remarks on computer-aided design, and they will simply appear in the record, with your permission. I would like to address briefly the question of liability.

An inquiry into structural failures of publicly occupied buildings must also take into consideration the professional liability of architects and engineers. Unlike the situation 25 or 30 years ago, when design professionals were regarded as having a duty only to their clients, and when the completed and accepted rule generally transferred all responsibility to the owner upon completion of a structure, design professionals now anticipate that they will become involved in litigation, whenever there is a building failure, regardless of the apparent cause of the failure or the amount of time elapsed since services were last performed on the project.

As a result of the increasing cost and complexity of buildings and their component systems, the desire to use new but unproven technology to contain building costs or to improve their habitability is great, at the same time, the litigious nature of modern society demands a source of recovery for every injury or damage almost regardless of fault. With the incremental changes in liability law, architects and engineers have been placed in a position where the risks involved in designing buildings threaten to outweigh the value placed on their services by clients.

AIA and the professional engineering societies have attempted over the past 25 years to address those risks through loss prevention programs, by encouraging the use of properly drawn contracts, through the establishment of a unique professional liability insurance program, by securing statutes of limitation, et cetera.

Let me cite a few of the problems associated with the professional liability of architects and engineers:

First, over the last 2 years, there has been a marked increase in both the severity of claims and especially in the frequency—up from 36 percent in 1978, to 45 percent in 1980. This means almost half of the insureds can expect to have a claim in the next 12 months. This will undoubtedly affect the cost and availability of insurance, as well as the number of firms who will be uninsured or underinsured.

When you stop to think about 45 percent of the insureds in my profession can expect to have a legal claim in the next 12 months, there are two possible conclusions.

One is that 45 percent of my profession is incompetent. The other is that something is wrong with the system. The buildings which have fallen, the building teams have been represented by some of the best in my profession, Mr. Chairman. That is an important thing to remember.

Second, changes in the insurance market and the ability of the insurance industry to respond to our needs continue to be major concerns for us. Over the last 25 years, 20 insurance companies have entered this field, but most have withdrawn. There are currently only seven carriers in this volatile market. Of those seven, we know that three have gone through major corporate shifts in the last year. Thus, even the continued availability of insurance from a number of these carriers is uncertain.

Third, we cannot ignore the state of the economy and its relationship to this problem. Architects and engineers are the first to feel the effects of an economic slowdown. As clients put off plans for construction, the insurance premiums we pay, which are based on the prior year's volume of business, take a larger bite out of dwindling fees. Also, as the economy moves into a recession, construction claims tend to increase in both frequency and severity. Our problem is that we do not think we can continue in this litigious environment.

Mr. Chairman, your problem is that we may find a way to do it that will not serve the best interests of society. If civilization is to be judged in large measure on the buildings that it builds, our legacy may be far less than what we really are.

As the committee is aware, the safety record of the U.S. design and construction industry in providing an esthetic yet functional built environment is one envied worldwide. This exceptional achievement has been compiled at the same time that great strides in design material use and construction techniques have occurred.

A major reason for the success of the construction industry in building billions of square feet of safe, yet innovative space is the constant concern for improvement and safety by the design professions and construction community.

I know of no profession where the protection of the safety of the public is of greater concern than the architect and engineering profession, Mr. Chairman.

In response to the increasing professional self-evaluation and concern by the design and construction community to the life safety aspects of building design, the AIA Board of Directors, in December 1981, created the AIA Life Safety Design Task Force. The task force was given the charge to conduct a general overview of the life safety subject as it relates to building construction.

Historically, the public has seen the architect in the context of master builder. This is to say that the architect is often placed in the role of one who has total control over the construction project, from early design stage to completion of construction.

This expectation of the general public has not kept pace with the reality that the modern practice of architecture is multifaceted.

The architect has a defined, but shared responsibility for the entire project. Many decisions which affect life safety are made by others—owners, public officials, code writers, lending institutions, building users, product manufacturers, and society.

The AIA applauds your efforts to examine all of the varied elements involved in building failures and to explore potential ways to deal with the myriad of problems associated with such failures.

On behalf of the AIA, I offer our resources to the committee in its further exploration of this matter.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Cooper follows:]

EXAMINING STRUCTURAL FAILURES IN PUBLIC FACILITIES, PREPARED STATEMENT BY
JEROME M. COOPER, FAIA

Mr. Chairman, my name is Jerome M. Cooper, FAIA. I appear today on behalf of The American Institute of Architects, the association representing the architectural profession. I am president of the Atlanta architectural firm of Cooper Carry and Associates, Inc., a firm active in the design of many types of public facilities including educational, commercial, multi-family housing, health care, and detention facilities. As a former member of the AIA Board of Directors and the Institute's Long-Span building panel, I greatly appreciate this opportunity to appear before the Committee and to contribute to these two days of valuable hearings.

The AIA supports the Committee's efforts in examining the underlying causes of structural failures in public facilities during the last six years and offers its extensive resources toward improving the structural integrity of the built environment. By widening the scope of the Committee's investigation beyond particular failures it greatly increases the usefulness and importance of its findings to the construction industry and the public at large.

While public attention to building failures has clearly been heightened during recent years, buildings have collapsed since mankind first began to build. General reasons for these failures may include a wide range of factors and how they interface.

To begin an examination of areas possibly contributing toward structural failures, one must scrutinize factors such as technical, legal, materials, management, contracting, economic organization, procedure, financial, and quality control methods. Simply put, collapse occurs because materials deteriorate; because buildings are struck by wind, earthquakes, snow, floods or other natural phenomena; because of overloads, fires and explosions; because of lack of maintenance or improper use and because of errors in design or construction. On occasion, a specific circumstance may provoke a collapse; it is not often, however, that one can attribute an entire collapse to a single cause. Buildings deteriorate. Occupancy requirements shift. So do loadings, exit and fireproofing requirements and energy requirements. The resulting characteristic of continuous change in buildings places special demands upon the owner, architect, engineer, contractor, inspection agency and maintenance personnel.

Much of this can be said of any structure. But because of the far-reaching consequences -- including major threats to life and property -- a collapse is of special concern when it happens to a large public arena. Auditoriums, sports stadiums, gymnasiums, theaters, large places of worship, airplane hangers -- these are buildings which may shelter tens of thousands of people at any one time and represent tens of millions of dollars in capital investment. Perhaps of most importance is the confidence and psychological well being which must be guaranteed our citizens by the integrity of the structures they inhabit. All of these

considerations demand continued attention and improvement by those of us in the construction industry as we serve the aesthetic and infrastructure needs of the nation.

The AIA believes that many factors are involved in the structural integrity of a building. Before specific reasons for structural failure are examined it is important to understand the architects' role, the process of design and how it relates to construction quality. Even in the most conventional of buildings, the design, construction and occupancy phases of a project's development are related. Accordingly, a strong process control system should be implemented. Such a system usually involves four basic interests: those of the owner, the design professional, the general contractor and the operator of the facility. These parties coalesce to form the building team, with delineated responsibilities to each other and the public.

As a first step in establishing an effective construction process control system, it is valuable to examine the manner in which the building team is formed to carry out the design and construction of a given project. Amongst the duties of the individual parties to a construction project are:

The owner. As client, is responsible for telling the design professionals what kind of building he needs. The owner is also responsible to the general contractor for timely payments and to the public for providing and maintaining a safe building;

The architect and engineer. Aside from project design, are responsible also for proper observation of field construction;

The contractor. Is responsible to the owner for erecting a building within an agreed upon budget and schedule, and has responsibility to the public for constructing a safe building.

The operator. Is responsible for seeing that a building runs safely and economically.

Newer types of construction team organization have led to non-traditional relationships among team members. This can create a difference in emphasis on some aspects of the project, and may modify the team members' responsibilities.

For example, construction management and design/build types of team organization tend to stress tighter construction schedules and earlier determination of construction costs. Sometimes this is done to the detriment of design innovation or of the thoroughness with which documents are prepared. Moreover, the rise of intermediaries (such as the construction manager or the design/build contractor) between the owner and the design professional could inhibit the free flow of information between them. As a result, their respective duties may on occasion become clouded.

If the owner is to select a team organization which best suits his goal of structural integrity, he should understand the strengths and weaknesses of each type of organization and the duties and responsibilities of each team member.

Also, the design professionals on the building team should be led by a "generalist" -- someone who has an overview of the project and a sense of the links among its various parts, and is aware of the context in which the project is to be built.

THE DESIGN PROCESS

Controls aimed at securing a safe structure should begin as soon as the owner sets the parameters for his project (schedule, budget, team organization).

The first phase is design. Design is not necessarily a logical, routine sequence even on conventional projects -- let alone on a building as complex as long-span. In the words of one engineer: "Design is a constant rehashing ... How many times do you make a change in the design and not go back and pick up all the threads that got you to that point to begin with?"

The chance for this type of omission clearly exists for conventional buildings. Since such projects are ordinarily developed in self-contained phases, an orderly checking process should uncover this type of defect and remedy it in time.

In a construction management and a design/build framework, however, in which construction often begins before all construction documents have been prepared, checked and coordinated, the opportunity for this type of omission is especially high. And because of the unique demands of a long-span building and the special links

among its parts, this type of omission can lead to conditions that could become critical.

As a safeguard, some projects have involved design checks by third-party, independent engineers. Professional reactions to such design reviews have changed over the past few years from resistance to cooperation. At one time there was a feeling in the profession that when someone was hired to check an architect's design, it created personal difficulties between the project team members. Now, the more common attitude today encourages review and quality control.

Still, the project team is the best one to do the checking, and the existence of a design review process on a project neither relaxes the checking process by the original design team nor relieves that team of its responsibility.

Independent design reviews should not be mandatory but should result rather from professional judgment by the design team and by informed consent of the owner.

Views among government bodies such as city building departments as to the degree of reviews and approvals they provide on project drawings and specifications have varied widely. Some typically call for third-party design checks before issuing a building permit; others provide only perfunctory reviews. Even so, many owners and some architects and engineers tend to over-rely on

review of project documents by municipal or other building officials. This faith may stem from the false idea that when a building official reviews project drawings and specifications and issues a building permit, the result is some form of irrevocable approval which transcends the requirements of the applicable building code.

Accordingly, design professionals should inform their clients that building codes are subject to judgment and interpretation by building officials.

The relationship between the design of a project and its construction methods and sequences has long been a matter of concern for design professionals.

The role of the design professional is clearly of major significance to the construction project team and the building's structural integrity. While many factors impact on the building's performance, including those already mentioned, I would like to now focus the Committee's attention and our remarks to a number of problem areas. These include long-span structures, codes and standards, building failure documentation, procurement of A/E services, and design professional liability. In addition to my written and oral remarks I would like to submit for the hearing record documents useful to those concerned with the issue at hand.

LONG-SPAN STRUCTURES

The past few years have seen several collapses of long-span structures. The major difference between a long-span and short-span structure exists in the lack of redundancy of structural elements. Many long-span structures have relatively fewer major structural elements. Hence, should one of these structural elements fail, there are fewer alternative paths of load resistance than would be found in most short-span structures. Another characteristic of such structures is that they generally house a large number of people at one time.

As a result of the collapses, The American Institute of Architects in the fall of 1979 convened a professional panel of prominent architects, engineers and contractors, and asked them to review the procedures for the design and construction of buildings with large, column-free interior spaces, and then to develop recommended actions which could lead to a reduction in the element of risk. The panel did no technical investigation of specific collapses, nor did it attempt to find fault or place blame. Since each construction project has unique requirements, the panel recognized that architects, engineers, contractors and others involved with a project must use proper professional judgment apart from any specific conclusions contained in their report. However, the panel's report (entered for the hearing record) does attempt to provide some guidance to design pro-

professionals for reducing the risk of collapse of long-span structures. The report recognizes that collapse of long-span structures can be attributed to three main subject categories:

1. Procedural Conditions

- Nontraditional methods of design and construction
- Total or partial curtailment of onsite presence and other construction phase services by the design professionals
- Inadequate post-construction building maintenance

2. Technical Conditions:

- Unconventional use of materials
- Design changes
- Unusual construction erection methods
- Lack of structural redundancy (alternate paths for structural stresses)

3. -Natural Conditions:

- Harsh weather
- Deterioration due to aging of materials

Several other factors were accentuated by the nature of long-span buildings. These included (1) progressive collapse (where the failure of one structural member overloads another, causing further and sequential failure) and (2) the special sensitivity of long-span designs to secondary stresses. For the purposes of the report, secondary stresses were defined as those caused by deflection and the interaction of building elements. Various experts also pointed out these added secondary effects: expansion or contraction due to heat or cold, snow drifts, ponded water, air infiltration, vibrations and general operation of the structure. Any or all of these influence the structure's capacity to remain standing.

Individually, none of these factors and conditions necessarily caused collapse, but they did show that long-span buildings are quite different from conventional, average-span structures.

What, then, are the features that mark a long-span building? Identifying these features and showing how each influences design and construction are important first steps.

Uniqueness of Long-Span Structures

Views differ as to what makes a structure long-span. Sixty feet for an office building is a long span. Sixty feet for a gymnasium is not a long span. Structural material is also a factor. Sixty feet may be a long span for a sawn timber beam, but a short span for a steel beam.

The panel also identified the following features which distinguish long-span from other structures. It pointed out, however, that these features are not necessarily primary or secondary causes of long-span construction problems.

Lack of Redundancy

Most short-span structures have alternative means of structural support. Many long-span structures, by contrast, have relatively fewer major structural elements, and fewer alternative paths of load resistance. This lack of redundancy makes the long-span structure more vulnerable to general collapse in case of accidental overload of member weakness. Long-span structural systems, according to testimony before the panel, "utilize the material in the structure to the maximum." As each structural member or "joint" becomes responsible for a larger area, its structural importance increases. The consequences of failure should, therefore, be evaluated separately, by using an increased factor of safety, making a

progressive collapse study, and/or resorting to increased quality assurance during construction.

In other words, the failure of a member or joint in a long-span structure tends not to remain localized; but to impinge on a far greater area of the structure than does the failure of a member or joint in a short-span structure.

Danger to People

Buildings of the types studied by the panel were made long-span for the express purpose of housing a relatively high population density, such as at sporting or cultural events. When analyzed, this translates into a larger than normal number of people per connection of structural members. Expressed in such terms, the potential consequences of failure of such connections or members points to a need for special care in design, construction and maintenance, as well as (a) provision of alternate means of supporting structural loads, (b) an increased factor of safety or (c) more intensive inspection of the completed structure.

Buckling and Instability of Members

Stresses in compression members of long-span structures are limited by local buckling, member buckling, or general instability. Interconnected roof decks used as roof diaphragms are sometimes not directly connected to members subjected to compressive stresses. Resistance to buckling of an element depends on its own stiffness of adjoining elements and connections, the initial straightness of the structure, and the deflection caused by

loads. Therefore, the stiffness of diaphragms, bracings and supports, and the flexibility of the connections, should be considered in the design. For example, some roof decks which may be used to adequately brace short spans may not be stiff enough to adequately brace long-span structures. The initial straightness of the structure should be verified during construction.

Leading Edge of Technology

The panel felt that none of the basic structural systems of the five buildings studied could be defined as surpassing the frontier of existing knowledge. Hence, "leading edge" factors were not believed to be present - or contributing causes - in those cases.

Long-Span Conclusions

A. Upon conclusion of the Long-Span Panel's work the panel concluded that added study and development of guideline materials is desirable. This would further improve the knowledge and procedures used by those involved in producing and using long-span buildings, thereby helping to obviate previously encountered problems and contributing results of important national significance. The panel members consequently reached the following additional conclusions:

B. That existing knowledge should be correlated to produce the following:

1. A special series of guideline documents and practice aids to assist design practitioners in fulfilling the special requirements of long-span design and construction.

2. A project delivery management manual for long-span design and construction to cover all members of the building team, and including tasks, responsibilities, checks and alerts. Such a manual should be geared to traditional as well as newer delivery methods and should recognize the "trade-offs" inherent in each of the methods.

C. That research is needed to uncover new or improved knowledge and practice tools. The panel believed such an effort could involve institutions, professional societies, individual design professionals or their firms, as well as other groups such as construction contractors and standards-making bodies. Specific research objectives would include:

1. Develop comprehensive, coordinated building code requirements covering long-span design and construction. Concurrently, develop data to stimulate promulgation of a national standard by a recognized standards organization covering longspan design criteria, including field testing standards.
2. Develop guidelines for progressive failure analysis investigations on long-span projects.
3. Develop recommendations relating design safety factors to anticipated levels of field control. Specify degrees of redundancy.
4. Develop practice materials to create among designers greater awareness of the impact of secondary factors on the performance of the long-span structure.
5. Develop guidelines for design review of the architect's and engineer's structural design and calculations. Include special implications of design decisions on field construction.

6. Develop guidelines dealing (a) with field and (b) with laboratory testing of long-span structural components and connections.
7. Develop recommended course materials for use by architecture and engineering schools stressing the special and procedural aspects appropriate to long-span buildings.
8. Produce guidelines for developing documents for erection procedure requirements for long-span projects.

CODES AND STANDARDS

A critical element in any discussion of structural integrity is the codes and standards process. Codes are developed in the public interest by states, cities and private model code writing groups. The model codes are designed to be adopted basically as written, possibly with minor variations, or to be used as a basis for local or state-adopted codes. The model code development system has helped to bring about more uniformity in codes. Despite the efforts of the model code groups, the building regulatory system in the United States remains a patchwork of ad hoc regulatory processes which is in need of coordination and uniformity.

Building codes do affect the structural integrity of buildings by setting some design criteria. The building's structural design can be influenced by codes which specify such things as design loads for a use or region, roof slope, maximum deflections, and fire protection for structural elements. An obstacle, however, to a clearcut design approach is the multitude of codes that can apply to one project. The regulations may comprise several volumes or sets of regulations, each volume or set covering some aspect of a building such as size, structure and configuration, electrical, plumbing, and mechanical. The local or state fire official, in addition, often seeks to modify the building code promulgated by a jurisdiction.

Besides building codes, the design professional is confronted with a wide range of local housing codes, environmental protection

rules, fire prevention codes, rehabilitation requirements, sanitation requirements, and other regulations which may or may not be enforced by the same agency that enforces the building code. In addition to a wide variety of local regulations the design professional faces state regulations which may overlap and conflict with local regulations. Compliance with certain federal standards is mandatory and if federal funds are used to fully or partially finance construction, additional federal regulations must be met. Insurance groups impose rules directly upon construction, and by a means of sliding premium scales, they enforce a series of de facto regulations. Finally, mortgage groups impose additional regulations on construction as a means to guaranty their investments.

How does this relate to structural failures? Since many structural failures are caused by a combination of events, it would be difficult to place all of the blame for structural failures on the building regulatory system. However, it is apparent that when a design professional spends his or her time trying to wade through the confusion and conflicts associated with this country's building regulatory system, less time is available to spend on architectural and engineering thinking. The task is often frustrating, costly and time consuming.

In addition to the need for better uniformity in the building regulatory system, potential technical conflicts in the codes often exist. An example of this is the conflict between designing for both earthquake and fire. The primary conflicts result, on

the one hand, from the added fire safety provided by heavy structural systems and airtight joints between interior elements; on the other hand added earthquake safety is provided by lightweight structural systems and relatively loose joints between building elements.

The characteristics of certain structural materials make their use desirable for fire safety. Heavier columns have higher fire-resistance ratings than lighter ones because they can absorb more heat. For example, steel columns encased in more than two inches of concrete for greater mass provide sufficient fire-resistance. In addition to adding heat-absorbing mass to the columns, the concrete "fireproofs" the steel. Although steel is noncombustible and does not contribute fuel to a fire, it loses strength and can fail when subjected to the temperatures easily attained in a fire. Therefore, whereas on one hand steel's flexibility makes a steel frame building a desirable structural type in earthquake-prone regions, adding concrete to the columns for fire safety makes the columns less flexible than is preferable for earthquake design.

DATA ON BUILDING FAILURES

A systematic understanding of past building failures would go a long way to prevent past mistakes from being repeated. However, up to now, there has been no central archive on the causes of building failures or systematic analysis of the nation's building failures, similar to the Swiss study of 800 building failures over a 16 year time period.

The reasons for this lack of documented research are many. First, many materials and subsystem failures go unnoticed or undocumented in the building trade or the popular press. Secondly, court proceedings and years of protracted litigation frequently prevent information on probable causes from being released to the general public and the design community.

However, the independent investigation of the Kansas City Hyatt collapse by the National Bureau of Standards (NBS) was an exception in many ways. The investigation actually replicated the structural components found in the hotel. The results from the investigation were published in major newspapers and trade publications in a relatively short amount of time. The results from the investigation were also released before the litigation had been completed.

However, like the results from other building failures, the NBS report will not go to a single place for archival or analytical purposes. The NBS findings will not automatically fit into a larger information base on building failures.

Hopefully, this lack of an information base will be remedied soon. The National Science Foundation (NSF) is now processing a grant for the Engineering Performance Information Center (EPIC) which will be a repository for information on all types of building failures. It will be housed at the University of Maryland and will be jointly operated by the civil engineering and architecture departments. When it is operational, it should be a valuable source of information for building researchers, engineers, architects, attorneys and insurance companies.

It appears that the National Science Foundation hopes EPIC will be self-sufficient after about two years. NSF hopes that engineers, architects, insurance companies, and other technical organizations will supply data to EPIC at low cost or in exchange for user privileges and the need for NSF support will disappear.

While the AIA does not advocate limitless funding for EPIC, it believes that the economic health of the construction industry may prevent the industry from contributing its full share for the startup costs of EPIC. Therefore, if this Committee should conclude that the EPIC program is an appropriate use of taxpayers funds, it may see fit to encourage NSF to fund EPIC beyond the two year level, if the Center still needs some support.

COMPUTER-AIDED DESIGN

Computers are an integral part of today's design process. They perform complicated engineering analysis of structural components, which might have been impossible or extremely expensive in precomputer days. They also save time and money during the design process.

However, the AIA's long-span report warned that the use of computers must not supplant human involvement in the design process, especially in long-span structures. Members of the AIA panel on long-span buildings believed that total reliance on computers provides an opportunity for "losing the feel of structural forces at work" and that retaining the feeling of the forces at work on a building is extremely important. It provides the designer with the opportunity to sense a flaw or error in basic assumptions upon which the building's structural safety is predicated.

For the building's safety, all the calculations must be correct and the basic assumptions must be appropriate. To produce a structurally sound building, the designer must analyze the big picture of how the structure behaves. The designer must also look at the forces that work on the building, such as the laws of gravity and the total sum of forces at work. This type of analysis can only be obtained through human involvement in the design process.

PROCUREMENT

Codes and Standards provide for a certain level of safety to building users. However, they can not be looked to as absolute assurance of a safe building. We believe that there is no substitute for the highest quality technical and design skills. This is why the AIA has supported the federal government's procurement of architectural and engineer services based on the qualifications of the design professionals.

There are obvious quality and life safety reasons why the federal government, and many states, have formalized their A/E procurement procedures with laws that specifically exclude A/E procurement from competitive bidding requirements. Public sector building projects involve public health and safety considerations. Professional design services involve many intangibles such as technical knowledge, aesthetic judgment and decision-making skills that are difficult to compare on a "complex project" basis.

Since 1972, Public Law 92-582, commonly known as the Brooks Law, has an outstanding record of providing for safer public sector buildings by stressing quality design control through the A/E selection process.

Congress enacted Public Law 92-582 to assure that there was maximum competition in the A/E selection process. This law requires that all projects must be publicly announced so that every interested firm has a chance to compete. The competition then centers on which firm has the highest technical ability to

best fulfill the government's needs. This is the first level of competition and it is the most important because the government seeks the most qualified firms for its projects. Because so much depends on the A/E design -- that is, large construction expenditures will be made to implement the A/E's work -- it has proven very successful for the government to select the firm best able to satisfy the government's needs within the budget.

Once the most qualified firm is selected, a second level of competition occurs when the government and the selected firm negotiate the scope of work and the professional fee. If an agreement cannot be reached on a fee that the government determines to be fair and reasonable, negotiations are terminated.

The next most qualified firm is then selected for negotiations and the process continues until an agreement can be reached.

Congress had this to say about the process:

The system favors selection of the most skilled and responsible members of these professions. Competition for Government contracts is based on qualifications and experience -- terms of competition that qualified members of any profession or field of endeavor are willing to meet. Under this system, A/E's are under no compunction to compromise the quality of the design or the level of effort they will contribute to it in order to meet the lower "fee" quotations of other A/E's. They are free to suggest optimum design approaches that may cost more to design, but can save in construction costs and other wise increase the quality of the building or facility to be constructed.

This system protects the interests of the taxpayers. Having won the competition on the basis of capability, the winning A/E must then negotiate his fee. He must demonstrate on the basis of projected costs that his fee is fair and reasonable. He must accept whatever adjustments the Government demands if he wishes to obtain the contract. He knows that if he holds out for an unfair or unreasonable fee, the Government will terminate the negotiations and award the contract to another A/E at a fair and reasonable price.

It is the Institute's recommendation that the Committee strongly endorse the current Brooks Law A/E selection procedure for professional services in its final report and that the Congress maintain its firm commitment to quality design as embodied in PL 92-582.

LIABILITY

An inquiry into structural failures of publicly occupied buildings must also take into consideration the professional liability of architects and engineers. Unlike the situation twenty-five or thirty years ago, when design professionals were regarded as having a duty only to their clients, and when the "completed and accepted" rule generally transferred all responsibility to the owner upon completion of a structure, design professionals now anticipate that they will become involved in litigation whenever there is a building failure -- regardless of the apparent cause of the failure or the amount of time elapsed since services were last performed on the project.

As a result of the increasing cost and complexity of buildings and their component systems, the desire to use new but unproven technology to contain building costs or to improve their habitability, the litigious nature of modern society which demands a source of recovery for every injury or damage almost regardless of fault, and the incremental changes in liability law, architects and engineers have been placed in a position where the risks involved in designing buildings threaten to outweigh the value placed on their services by clients. AIA and the professional engineering societies have attempted over the past twenty-five years to address those risks through loss prevention programs, by encouraging the use of properly drawn contracts, through the establishment of a unique professional liability insurance program, by securing statutes of limitation in the various states, and other means.

To date, the professional liability problem for architects and engineers has been especially complex because of the wide variety of sources from which claims can arise. There are many influences which affect the design professional's daily practice in this regard. Professional liability claims against architects and engineers can result from alleged negligence in the project design or in the preparation of the drawings and specifications. They can arise from services performed during the construction phase while acting as the owner's agent; or from allegedly improper specifications for new materials and products, or from specifications for traditional products used in a new way without adequate testing; or from the increasing scope of government regulations such as building codes or standards, environmental laws, and regulations related to occupational safety; or from the constraints imposed by time and money in an era of high inflation and interest rates which result in demands to complete projects more quickly than normal; or, finally, from the changing attitudes of the courts and society in regard to the accountability of professionals for the consequences of their acts.

Let me cite a few of the problems associated with the professional liability of architects and engineers:

- First, over the last two years, there has been a marked increase in both the severity of claims and especially in the frequency -- up from 36 percent in 1978, to 45 percent in 1980. This means almost half of the insureds can expect to have a claim in the next twelve months. This will undoubtedly affect the cost

and availability of insurance, as well as the number of firms who will be uninsured or underinsured.

● Second, changes in the insurance market and the ability of the insurance industry to respond to our needs continue to be major concerns for us. Over the last twenty-five years, twenty insurance companies have entered this field, but most have withdrawn. There are currently only seven carriers in this volatile market. Of those seven we know that three have gone through major corporate shifts in the last year. Thus, even the continued availability of insurance from a number of these carriers is uncertain.

● Third, we cannot ignore the state of the economy and its relationship to this problem. Architects and engineers are the first to feel the effects of an economic slowdown. As clients put off plans for construction, the insurance premiums we pay, which are based on the prior year's volume of business, take a larger bite out of dwindling fees. Also, as the economy moves into a recession, construction claims tend to increase in both frequency and severity. Claims that normally would not have enough merit to pursue are vigorously litigated in hopes of obtaining a recovery from anyone and everyone involved in a project. We cannot avoid getting caught in the middle of these disputes; even when the claims are frivolous and the design professional is ultimately cleared of any negligence, a great expense is involved in defending the case. Because of our high deductibles and their multiple application, a large part of these defense

costs come out of pocket and not from insurance.

In 1980 the accounting firm of Deloitte Haskins and Sells conducted the Design Professionals Liability Study from which much of this data is provided. A copy of that report is being entered for the record.

Legislation

In the Congress, AIA and the engineering societies are supporting legislation in the House and Senate -- H.R. 248 and S. 1081, which we call the "Service Liability" legislation -- which would permit architects and engineers to defer taxation of revenues set aside to help pay for the costs of defending professional liability claims.

In our opinion, there are three benefits to be derived from this proposed legislation:

1. As the nature of the construction industry -- and the architects' and engineers' services -- is so extraordinarily cyclical, a firm with a good profit picture today can be unable to meet its obligations in another year. This proposed legislation will provide an orderly mechanism to accumulate funds in good times in order to pay deductibles whenever necessary. This will be a benefit to the public as well as the professionals.
2. It would allow architects and engineers to more easily afford to pay multiple deductibles in those years in

which they might be faced with more than one claim.

3. After ceasing to practice, it would allow design professionals to pay the costs associated with claims, with funds accumulated during years of active practice, thus alleviating the burden created by the necessity to continue to pay professional liability insurance premiums as a measure of postpractice protection. This burden thus would be alleviated without affecting recovery by consumers in situations involving valid claims.

We believe that this legislation will enable more firms to become better equipped to deal with these financial realities. It will not produce an immediate or dramatic reduction in professional liability insurance premiums. In fact, the short term effect would be to increase total professional liability related costs as design professionals make contributions to trusts while continuing to pay for insurance at current rate levels.

In all of this, as well, the public has a vital interest. There can be little doubt that members of the public as well as professionals' clients are directly benefited by architects and engineers having financial resources in the event of a professional liability claim. If a person is injured or damaged by a design professional's negligence, there can be no meaningful recovery in the absence of insurance or personal assets. If a professional has chosen not to purchase professional liability insurance because of the expense, or has insufficient resources to pay

the deductible, the injured party rather than the professional will suffer the financial burden. We see S. 1081 and H.R. 248 as a solution to this very real problem. The tax qualified reserve should encourage design professionals to become better equipped to deal with the unfortunate consequences of professional liability.

Although it appears unlikely that such legislation could pass in the current session, we believe that, if enacted, this legislation would encourage design professionals to set aside funds to cover at least the high deductibles characteristic of professional liability insurance, and to raise their limits of coverage so that there will be a source of recovery for meritorious claims. We believe that design professionals and those who are affected by the professional judgments they render in the course of designing a building are deserving of special consideration in this regard and commend this bill to your attention as one small part of solving the problems associated with building failures. Further information on this legislation is available if you desire.

CONCLUSION

As the Committee is aware, the safety record of the U.S. design and construction industry in providing an aesthetic yet functional built environment is one envied worldwide. This exceptional achievement has been compiled at the same time that great strides in design material use and construction techniques have occurred. A major reason for the success of the construction industry in building billions of square feet of safe, yet innovative space is the constant concern for improvement and safety by the design professions and construction community.

In response to the increasing professional self-evaluation and concern by the design and construction community to the life safety aspects of building design, the AIA Board of Directors, in December 1981, created the AIA Life Safety Design Task Force. The Task Force was given the charge to conduct a general overview of the life safety subject as it relates to building construction. The Task Force will recommend specific policy and program options to the AIA Board of Directors. The Task Force Report will be available early next year and should include valuable educational information for the profession in its unending search for improved building safety.

Historically, the public has seen the architect in the context of "master builder." This is to say that the architect is often placed in the role of one who has total control over the

construction project from early design stage to completion of construction. This expectation of the general public has not kept pace with reality in that the modern practice of architecture is multifaceted. The architect has a defined, but shared responsibility for the entire project. Many decisions which affect life safety are made by others -- owners, public officials, code writers, lending institutions, building users, product manufacturers and society. The AIA applauds your efforts to examine all of the varied elements involved in building failures and to explore potential ways to deal with the myriad of problems associated with such failures. On behalf of the AIA, I offer our resources to the Committee in its further exploration of this matter.

Mr. GORE. Thank you very much, Mr. Cooper.

The subcommittee will withhold questions until we have completed the panel, but let me just ask one brief question now.

Are you saying, in your discussion of liability, that concerns over liability have created circumstances where the architect will withdraw from the site, from continued supervision, whereas, in the past the architect might have continued to maintain an oversight role?

Mr. COOPER. In part I am saying that. Most architects who have received legal advice as a result of litigation or otherwise are advised by their clients, I believe, that they go onto the site and they perform an observation of construction activities as opposed to actual supervision of construction activities as it had been maybe 15 or 20 years ago.

The reason for that is that there is some legal aspect, legal connotation attached to the word "supervision" that does not attach to the term "observation".

Quite frankly, we find ourselves moving away from liability because we seem so inadequate to handle it and while we want to be in the field and we want to observe what is going on, we are not financially equipped to deal with the enormous claims that can come out of taking responsibility for the contractor's failure to do something or failure to perform.

Does that answer your question?

Mr. GORE. Yes, it does, but it certainly provokes a lot of other questions.

If the system for establishing legal liability for accidents that occur on the jobsite force the architect to change his traditional role and remove himself from a supervisory role and remove himself from responsibility for the kind of supervision and quality control that is necessary at a jobsite, who is going to take over that role?

Who is qualified to continue serving the function, the architect began, maybe no one? Maybe that is a big part of the problem.

Mr. COOPER. That is a large part of the problem, Mr. Chairman. I do not mean to imply that the architect is not visiting the job periodically and satisfying himself that the job is going on generally in accordance with the construction documents.

What I do mean to say, and I think that the AIA documents will bear that out, that the contractual arrangements that we entered into with our clients on the standard AIA contract form reflect the duties and responsibilities of the architect very clearly.

It is, precisely, that the architect does not take the responsibility for the contractor's actions or failure to perform on the job and that while we are visiting the job on a periodic basis we are not undertaking to ascertain if the work has been performed properly. It is our intention to attempt to protect the owner from poor work, however.

Mr. GORE. Well, we will hear next from the consulting engineers' point of view and I am told that the same situation prevails with regard to consulting engineers and that actually, in some cases, consulting engineers are advised by their lawyers not to set foot on the jobsite after a particular role has been performed.

Is that correct, Mr. Sandberg?

Mr. SANDBERG. That is correct.

Mr. GORE. Well, we will hear from your statement.

But wait 1 second. We have a vote in full committee. It will just take about 3 minutes because we are just down at the end of the hall because we are meeting at their sufference.

We will adjourn for 3 minutes and come back for your statement.
[Brief recess.]

Mr. GORE. The subcommittee will come back to order. You didn't believe it would be just 3 minutes, did you?

We will hear next from Harold Sandberg, representing the American Consulting Engineers Council. Mr. Sandberg, welcome. Please proceed, and if you want to summarize portions of your statement, the subcommittee would appreciate it.

Mr. SANDBERG. My name is Harold Sandberg. I am president of a 100-man consulting engineering company specializing in the structural design of bridges and buildings.

I am active in the American Consulting Engineers Council which represents over 3,800 engineering firms with practices throughout the United States and some foreign countries.

To give a little more credibility to some things I may say, I am an active member of the American Society of Civil Engineers and the American Concrete Institute. Currently serving on a national joint committee of these organizations which is concerned with the design and construction of concrete bridges.

I serve on a national committee of the American Railway Engineers Association that is charged with the writing, rewriting, and updating of the design specifications and code of practice as it relates to structures which will carry railroads.

I am also a charter member and past chairman of a unique organization called the Chicago Committee on High-Rise Buildings. This committee is concerned with the design, construction, maintenance, and management of high rise buildings. It includes members from every facet of the building profession, including managers and owners.

I am a past president of the Structural Engineers Association of Illinois and immediate past president of the University of Illinois, Civil Engineering Alumnae Association and currently on the Scholarship and Research Committee of the American Institute of Steel Construction.

I want to thank Mr. Ron Williams for visiting our office where he was able to see firsthand what we are doing. There he was able to talk with the young men who are engaged in the actual design process.

Admittedly, a structural failure has to be the fault of the structural engineer. However, I would like to explain briefly about the role of the structural engineer and how he is being hindered from properly performing his job.

Generally, and ideally, a structural engineer participates in the early on stage of design before the shape of the building or structure has taken place.

He works with the architect, the owner, the contractor, the construction manager, determining the optimum framework for a building, the story height, the column spacing, the type of materi-

al, the type of structural framing, the type of lateral wind resistance framing, the foundation, and so forth.

Continuing into the design stage he prepares complete plans and specifications that will be used by the contractor to construct the building.

Then, ideally, during the construction stage he is retained to provide regular, if not full-time, construction observation to insure that the construction is being done according to the plans.

Finally and most ideally, after the construction is done—but this happens very, very infrequently—he is retained to inspect the structure at frequent intervals to see if it is performing according to the design. That is a summary of the role of a structural engineer.

In my opinion, there are two classes of structural failures. One is due to improper design or construction. The second is due to old age. Today I want to talk about the first class. There are two things the structural engineer can do to prevent failures due to improper design or construction. First, he can prepare plans and specifications that are complete and foolproof. Foolproof means that the plans will eliminate any possibility of misinterpretation or misplacement by the contractor and misuse by the owner.

Clearly this is a difficult thing to do. This is not quality control that will eliminate errors. It is something else. It is best done in our office through an indepth review by qualified, experienced and high-priced engineers, several of them, in fact, who review the plans when they are almost complete to see that they do represent the most foolproof plans and specifications based on our past experience.

The second thing the structural engineer can do is to perform construction observation services. If he performs these two services, he will insure good structural performance under all except the most unusual of circumstances, which I would classify as acts of God.

Now, I would like to enumerate a few circumstances that are hindering, if not totally preventing the structural engineer from providing these essential services.

The first thing is the procurement of services. In the private field it is becoming more and more a practice for the owner and the prime consultant to shop around for the best price among several qualified engineers. And numerous engineers are equally qualified.

But this practice leads to price cutting. The owners hint that we know another structural engineer who would do it for such and such a price, why can't you? So you cut the price and then you ponder, "How am I going to do this job?" You sit down with the prime consultant and the owner and ask, "What about field observation?" They reply, "We don't need field observation. There is a construction manager's man on the job, or there is an architect's representative on the job. Aren't they qualified to do it?" And possibly they are, but they don't have the intimate knowledge that the designer has.

Second thing to be cut is the indepth review. They say, "You designed it according to the building code. What could be more complete than to fully design according to the code?" In fact, building codes are really a set of minimum standards and often use stricter

criteria. They also say, "Your plans are reviewed by the plan examiner of the local building authority, and isn't that enough?"

These then are the pressures that are put on the structural engineer. He has three choices. He can walk away saying, "I don't want the job," and that has been done. He can cut the scope as requested and do exactly what he agreed to do. Or he can accept the lesser payment and try to squeeze in some construction observation and some indepth review to the best of his ability. But it is not going to be as thorough as if he as fully compensated for it. He just can't afford it.

In the public sector things are better. Public Law 92-582 governs the selection of the designer by qualifications only and we really think it works.

But the negotiation of fee for design services has become not so much a matter of determining a reasonable price but of cutting the scope of services proposed by the designer to fit a budget that is set by the agency. And since most agencies have in-house engineers who can review plans and also observe construction, those are the first areas to get cut.

Then there is the relationship amongst the design team. There used to be a clear-cut relationship and the prime consultant, generally the architect, was in control. It has now become more a coalition of specialists and each one has his own little area where he is responsible. But what happens at the interface between one area and another? It is gray.

Neither party wants to accept responsibility there, and as you get more and more specialties there are more and more gray areas. It is pretty hard for the consulting structural engineer to see to it that what happens in those gray areas is not detrimental to the structure.

Contractors and designers are becoming adversaries and not partners. In fact many contractors are looking for problems in your plans. If there is a possibility for misinterpretation, believe me, they are going to make it. Then if something happens and you insist that it be remedied, they want an extra for it. There are some contractors who have a reputation for doing just that, deliberately.

In the past contractors would call up and say, "Can you tell me what you mean in this detail?" before they actually built it and we would be only too happy to explain it to them.

Mr. GORE. Now they are looking for a change order and a little more money.

Mr. SANDBERG. That is right. That is one way some contractors make a profit.

The problem with professional liability has been discussed, but I would like to emphasize that this is a liability problem not for errors and omissions in design. This is liability for accidents that happen during construction. We have been told that the best thing to do, the strongest defense is, "Don't be there so you couldn't have had a chance of seeing the possibility of an accident."

But if you do go on a job, "wear blinders, just go there to look at what you are supposed to look at. Don't let your eyes wander." If you do see something, "Go to the superintendent of the contractor and tell him "maybe there is something wrong." Don't say there is,

say, "Maybe there is something over there you should look at." Then beat it.

Mr. GORE. Your lawyers advise you to do that?

Mr. SANDBERG. Yes, and the insurance experts. And I don't think they said it jokingly. They really don't joke about such matters.

Before completing my remarks about regulations and licensing, I would like to make a quick comment about today's engineering graduates in response to your comments.

Today's engineering graduates are the cream of America's youth. There is no doubt about it, particularly when compared with my generation. I'm not sure I could meet the current entrance requirement of my university.

Knowledge, however, has multiplied many times. New techniques, new materials, require more attention. Yet the hours that are allotted to these technical subjects have been significant reduced. A 4-year graduate takes 30-percent fewer technical hours than we did when I went to school.

Consequently, the new graduate needs a continuing apprenticeship or training in his first few years on the job, and this is particularly true of a structural engineer.

Now, the best training that you can get is to do construction observation of structures on which you have participated in the design. But the opportunity to do this, as I explained before, is being more and more curtailed.

We at Alfred Benesch & Co. are still using our young people as construction observers, but we get sued at least once on every building that we design. Suits that have nothing to do with misdesign or misconstruction.

My concluding remarks concern regulation and licensing.

Structural engineering is only a branch of civil engineering. Every graduate civil engineer is exposed to at least a minimum amount of structural engineering. Consequently, all civil engineers feel that they have, and to a certain extent they do have, an expertise to practice structural design.

But with the multiplicity of new materials and new techniques structural engineering requires deeper and wider knowledge.

The State of Illinois and a few other States recognize this and have a separate licensing procedure for structural engineers. They are recognized as specialists and candidates are subject to 2-day exams that the other engineers don't have to take.

I believe this ought to be the rule for all States, not the exception.

I don't propose and don't advocate that the Federal Government control licensing. It is a responsibility of the States, but I think it could be encouraged.

The American Consulting Engineers Council has already been subject to regulation by the Federal Government. We have been sued by the Department of Justice Antitrust Division because of certain restrictions in our code of ethics. As a result we have to certify to ACEC that we do not practice these restrictions.

But as an individual structural engineer I must certify to some State board of registration that I am doing things that may be contrary to what I certified to ACEC.

As a practical matter our profession can live with this though I wouldn't want some lawyer to come and catch me at it. Such are the situations that regulations by multiple agencies generate. The Federal Government should get out of regulating professions.

There is a difference between commercial business where there is a need to insure against anticompetitive practices and in the professions where it is recognized that they are dedicated to serving society. The professions should be allowed to continue to govern themselves in accordance with the laws of the States.

I want to say it is a privilege to participate in this hearing. You are dealing with a very complex interaction between a great number of specialists. Every one of them has a different perspective, but I think the import of their views gathered together in one place is going to be a very good asset.

I hope that this will somehow be disseminated to the societies like ACEC, AIA, and ASCE, and so forth.

Thank you.

[The prepared statement of Mr. Sandberg follows:]

Testimony Of Harold R. Sandberg

Mr. Chairman and Members of the Subcommittee, I am Harold Sandberg, President of the Alfred Benesch Company of Chicago, Illinois. I am a registered professional engineer in Illinois and have been in the practice of structural engineering for 40 years. Accompanying me today is William J. Birkhofer, Director of Governmental Affairs of the American Consulting Engineers Council (ACEC).

It was my firm's privilege to participate with your staff in earlier field discussions concerning the consulting engineer's perspective on building failures. I am pleased to be here with you today to continue these discussions.

It is my understanding that these hearings will focus on the perspectives of design professionals, contractors, suppliers, building officials, owners and developers and the financial and insurance communities in order to establish the roles, responsibilities and interaction of each group within the building sequence. Although we do not believe there is any corrective potential in a comprehensive federal legislative remedy to the problem of building failure, there are undoubtedly specific problem areas for consulting engineers which Congress could target. We believe your interest and attention will also stimulate all of us who participate in the building process to find new and better means to communicate and cooperate.

With your permission, Mr. Chairman, I would like to focus today on several different areas -- architect-engineer procurement, .

working relationships, liability and regulations -- which potentially affect structural failure and building safety from the consulting engineer's point of view.

The seeds of a building failure can be sown in the very manner by which the consulting engineer's services are obtained. In today's cost-conscious world, both public and private clients feel increasing pressures from taxpayers, stockholders or their own pocketbooks to economize. This is not bad in and of itself, but when procuring architect-engineer (A-E) services, it can be detrimental and even perilous.

Ten years ago last month Congress enacted Public Law 92-582, the Brooks Act, authored by Congressman Jack Brooks, which codified longstanding A-E selection procedures. Now used by all federal government agencies and nearly half the states, these procedures emphasize selection on the basis of qualification rather than price. Here's how the selection process works under these procedures. Technical proposals are received from a wide range of A-Es for a particular project. A-E selection officials then choose a small number (usually three to six) firms based on an initial evaluation of their demonstrated understanding of services to be performed, past experience of the firm and its personnel in providing similar services, the personnel to be assigned to the project and related factors. A-E selection officials interview these firms and rank them on the basis of qualifications. The first-ranked firm is then invited to begin negotiations with the client agency. If a mutually acceptable

agreement concerning cost cannot be reached, negotiations are terminated and started with the next-ranked firm until a satisfactory agreement is reached.

These procedures work very effectively because they treat design cost as secondary until a clear scope of work is defined. At that point, the client (who is often at first unsure of what he needs from the engineer) and the consulting engineer (who is often at first uncertain about what the client/owner is asking him to do) more clearly understand one another's position and needs relative to the design requirements.

These procedures clearly recognize that design is a relatively small increment of the total building process when measured in dollar terms, but serves as the guiding force for the form, function, life-cycle cost and safety of the ultimate structure. The relatively small cost of design, the initial investment, has a tremendous leverage and impact on the far greater total life-cycle cost.

Detractors of these established A-E selection procedures, including representatives of the Office of Federal Procurement Policy (OFPP), maintain that interjecting price as a selection factor will have no impact on the quality of A-E services. They argue that there is no direct correlation between A-E fees and quality of services, there is no requirement to award A-E contracts to the lowest bidder and most government procurement officials can readily ascertain the trade-offs between price and quality in A-E selection.

We respectfully disagree on all counts.

In our experience, price-based A-E procurement does affect the quality of the A-E services because it tends to establish a minimum or "threshold" level of service that is not likely to be exceeded. Price-based competition also tends to affect the completeness of A-E services, meaning that additional soils/geotechnical investigation, seismic analysis, stress analysis and other special services which may serve to prevent building failure are often eliminated from the design process as useful but expensive "frills" that can be left out without compromising building design and structural integrity.

With respect to the other points, our experience, particularly with state and local government agencies, clearly illustrates that once price is interjected in architect-engineer selection it does become the dominant factor. The only purpose in wanting price bids is to force prices down by the threat of not being selected. The more important considerations of technical competence, design ability and creativity are abstract, difficult to define and hard to appreciate, understand and evaluate without extensive professional training and experience. Fee becomes the "convenient" and "absolute" way to evaluate proposals and technical competence is suppressed to the detriment of longer-term total facility costs. This phenomenon is complicated by the relative lack of familiarity of most procurement officials with contracting for A-E services.

Thus the process to select an architect or engineer can and does have significant impact on both developing the scope

of services and the mutual understanding and acceptance of the necessary level of design effort by the A-E and the building owner. Substituting price competition for the traditional A-E selection procedure is an ineffective and dangerous crutch that extolls price benefits at the expense of public health and safety. The benefits of or defects in A-E services often cannot be assessed until long after the services have been completed. Since they generally involve important public projects -- buildings, dams, hospitals, machinery and equipment -- choosing less than the best can be costly and endanger lives and property. These considerations are too important to be put on the price auction block.

After the selection process ends and a firm is chosen and contract signed, the working relationship of the design professionals involved plays an important role in determining the structure-to-be. A brief examination of this process and ways to improve the interaction and communication among the design professionals can be useful.

The consulting professional engineer typically works under contract not to the building owner but to the architect who serves as the project's prime contractor. While no one questions that over-all project management and control must be vested in a single entity, most often the architect, there are ways to ensure a clear delineation of responsibility, a more productive use of accountability and improved communication that can benefit the architect, the engineer and the building owner.

One such way is the development of a multi-prime agreement. This concept, now being discussed in professional circles, would allow a building owner to negotiate and contract separately with engineers and architects, thereby relieving the architect of his accountability for the engineer's technical design duties. The architect would still be responsible for over-all project management, but the consulting engineer would be given clear responsibility and authority to complete his technical duties and be directly accountable to the building owner for doing so. More clearly delineating separate responsibilities under separate agreements would be an advantage to both architect and engineer. It would lead to greater accuracy in assessing the exposure to liability risk, since the engineer would be free to interact directly with the building owner on matters relating to the building's structural engineering design. This would help enhance the concern for design quality and, hence, safety.

Quality control is another factor related to potential building failures. Builders are under constant pressure to finish projects as quickly as possible to cut or contain costs. Time pressures affect quality control. In general, consulting engineers do exercise high levels of internal quality control when developing building plans and specifications. However, they do not often have adequate time to fully review the work in progress. In addition, comprehensive quality control that includes an internal review by project managers, the engineering firm's department heads of different engineering disciplines and

the firm's principals is often felt to be an unneeded "frill" that is dispensed with in order to cut costs. The fact of the matter is that we are dealing with new building materials and techniques in ever-changing circumstances, often with technically competent yet unfamiliar personnel. While the pressures of time and money are always present, it is at this point in the process that the building owner must clearly appreciate the relationship between adequate quality control and building safety.

Choosing consulting engineer services on the basis of cost, rather than qualifications, invites design shortcuts that can lead to impaired structural integrity. But in an era of fiscal austerity, the effort to save money by comparing costs is increasingly commonplace. As in other areas, the costs of A-E services are increasing. One reason is the increasing cost of carrying liability insurance. This not only increases the competitive pressure to take more design shortcuts in an effort to stabilize prices, but also provides consulting engineers with a potentially perilous incentive to avoid innovation and, thus, liability risk.

Certainly, liability claims against design professionals are occurring more frequently and in larger dollar amounts than ever before. This issue is the top business-related problem identified in ACEC's 1981 professional liability survey of its member firms. In the face of escalating legal fees associated with claims and the ever-rising number of third-party and frivolous lawsuits, more and more consulting engineering firms are

deciding or being forced to decide to carry professional liability insurance.

The 1,400 firms responding to ACEC's survey reported that professional liability insurance costs an average 2.4 percent of gross billings. Although this cost is down from the 2.6 percent reported in the 1980 survey, the percentage increases as the firm size decreases. Those firms with one to five employees -- which comprise nearly half of ACEC's membership -- spend an average of three percent of their gross billings on insurance costs. Structural engineering firms cited the highest costs at 3.3 percent, followed by mechanical and geotechnical firms at 2.4 percent each, civil engineering firms at 2.2 percent and architectural-engineering firms at 1.8 percent.

Despite the cost associated with professional liability insurance, the survey showed that fewer consulting engineering firms are choosing to go without it. Still, 13 percent of the firms indicated that they have no professional liability insurance at all. Small firms are choosing this path more often than their big brothers in the business. Twenty-one percent of the firms with one to five employees do not have professional liability insurance coverage.

One reason why is the cost of deductibles. Most companies would prefer to buy insurance limits in approximately the amount of their gross billings and keep deductibles low enough to cover small losses they could realistically afford to pay from operating revenues. However, since the cost of insurance below the \$250,000

level is quite high, compared to additional coverage in excess of \$5 to \$10 million, they end up paying so much to keep the deductible low they cannot afford to pay for higher limits of protection.

This is particularly true for smaller firms. According to the ACEC survey, 72 percent of small firms had deductibles under \$5,000, while 68 percent of large firms with over 500 employees had deductibles over \$100,000. Matters look even worse when over-all coverage is examined. Of the small firms that were insured -- 21 percent had no insurance -- 40 percent had top coverage limits under \$250,000 and 66 percent under \$500,000. This is dangerous in today's climate of large judgments and escalating legal fees.

In case after case cited in the survey responses, firms noted that legal costs associated with claims outstripped the cost of eventual settlements. Firms reported a total of 530 claims filed against them during 1981, with 948 more pending. Of the resolved claims, the average cost was \$25,682. The average cost for each pending claim, however, was \$173,550. This cost differential can be explained partly by the fact that so few claims actually get to the courtroom. Of the 183 claims resolved, firms reported that 163 were resolved out of court.

This problem has led ACEC and other construction industry associations representing design professionals to support strongly the Service Liability Self Insurance Act. This act would let construction design professionals set up tax-exempt trust funds

to pay a portion of liability insurance costs. The funds would permit firms to raise their deductible levels, allowing the same premium dollar to purchase a higher limit of coverage.

What is finally needed to improve the professional liability problem is not as amenable to legislative resolution, but is vitally important nevertheless -- the public's perception of the engineering professional. A consulting engineer's duty and corresponding potential liability extends to hundreds, even thousands, of unknown persons. As far as the public is concerned, the acceptable level of care has come to be perfection, or at least the prevention of failures that cause major losses. This level of success has so spoiled the public that, unlike doctors or lawyers, engineers are expected to be infallible.

The public must understand that consulting engineering, like any other profession, requires judgments and creativity, as well as technical training. Engineers are human and do make mistakes; quality engineering follows when the engineer is permitted to use all of his or her talents. The public must learn that if they select engineers on the basis of cost alone they cannot expect to receive the highest level of engineering services.

A fourth area affecting price and, thus, building failure, is regulations. Federal regulatory actions in recent years, while not denying the importance of design quality, have tended to stress price -- with serious implications for building safety. Both the Justice Department's Antitrust Division and the

Federal Trade Commission (FTC) have legally challenged professional standards promulgated by professional societies on the grounds that these standards, intended to protect the public from overreaching and abuse, restrain competition and raise prices to the consumer.

In doing so, however, both the Antitrust Division and FTC have conspicuously failed to observe the following principles:

- There are vital differences between practicing a learned profession and operating a commercial business (which does not, however, mean the professions should be above the law); and
- When the law fails to recognize the differences between the client-professional relationship and the commercial buyer-seller relationship, the victims will be first the clients and public and secondly the professions.

Any analysis of professional conduct under federal anti-trust laws should recognize the public service requirements of the learned professions and take into account the effects of professional conduct on the public health, safety and welfare. Determining what type and scope of regulation is appropriate to ensure the quality and availability of professional services is most properly the states' responsibility. Unlike the FTC, state agencies have many decades of experience in this field.

"Professionalism" is used here in the old-fashioned sense of a learned vocation for providing many of society's most essential services -- public health, law, applied technology and science. Society has an enormous stake in the effective

performance of such services which, since they are highly specialized and require advanced training, most clients cannot evaluate.

During the early twentieth century, professional practices operated under the rule of the commercial marketplace -- without ethics, professional societies or peer review. To reverse the resultant adverse effects on social welfare, the states and professions themselves established codes of conduct, educational requirements and various other measures to ensure delivery of high quality, ethical professional services. These measures were necessary since professional services, by their nature, include public service objectives other than marketing a product at the lowest possible price. Although not perfect, professional regulation has worked very well for many years.

In recent years, however, the FTC and Antitrust Division have asserted they could do a better job of regulating the professions. Between 1972 and 1980 the FTC or Antitrust Division either filed suit or commenced investigations involving a wide variety of professional ethical standards nearly 100 times. These cases and investigations have dealt with such issues as whether there should be standards for entering into a profession and educating professionals, limitations on client solicitation, prohibitions on developing technical standards within a profession and abolition of professional ethics.

The number and scope of these lawsuits and investigations have imposed a major burden upon the professions, not only

because of the time and effort necessary to defend themselves against these claims, but also because of the enormous litigation expense involved.

The courts have not deterred these government enforcement agencies from trying to regulate the professions, even though existing antitrust laws were never intended to apply to the professions. In fact, the 1890 Sherman Antitrust Act, the 1914 Federal Trade Commission Act and the judicial decisions handed down since their passage focus exclusively on promoting competition and regulating commercial business. Thus, in determining the reasonableness of a particular commercial practice, traditional antitrust analysis considers only the effects of that practice on price and competition.

The Supreme Court has directly suggested that this mode of analysis may be inappropriate in the context of professional practices:

The fact that a restraint operates upon a profession as distinguished from a business is, of course, relevant in determining whether that particular restraint violates the Sherman Act. It would be unrealistic to view the practice of professions as interchangeable with other business activities, and automatically to apply to the professions antitrust concepts which originated in other areas. The public service aspect, and other features of the professions, may require that a particular practice, which could properly be viewed as a violation of the Sherman Act in another context, be treated differently.*

* Goldfarb v. Virginia State Bar, 421 U.S. 773, 788 n. 17 (1975).

Nevertheless, in the National Society of Professional Engineers case, the Supreme Court specifically held that the Sherman Act in its present form precludes courts from taking into consideration such factors as benefits to public safety, health and welfare when considering the reasonableness of professional standards which otherwise restrain competition. The Supreme Court stated that "(t)hat kind of argument is properly addressed to Congress" * We respectfully submit to the Congress that regulation of the learned professions should not be -- indeed, cannot be -- undertaken on the same basis as general commercial business regulation. The historic standards of professional practice must not be reduced to the marketplace standards of buyer and seller. Professional ethics must not be replaced with the commercial rule of caveat emptor.

In the professional context, shaving service quality merely to make it available at the lowest possible price not only is a questionable approach, but can also lead to disastrous results. In the design professions, the effects on public safety of an erosion in the quality of architectural and engineering services should be obvious. Judging professional standards -- designed to ensure quality service -- on the basis of their alleged effects on competition without permitting any consideration of the countervailing social benefits is worse than shortsighted; it is stupid.

* 435 U.S. at 689.

In fact, many professional standards and practices undertaken out of a legitimate concern for quality may appear to have adverse effects on competition, but may actually be the most efficient way to accomplish one of business regulation's ultimate goals -- delivering high quality goods and services at a reasonable cost. Indeed, many standards of professional practice, including the very standard struck down by the Supreme Court in the National Society of Professional Engineers case, directly reflect and parallel the requirements of longstanding federal law, policy or practice.*

Antitrust law can be adequately -- and most properly -- performed by the Justice Department and FTC enforcement is duplicative and perhaps inconsistent. Two federal antitrust agencies regulating professional ethics is at least one too many. If eliminating FTC jurisdiction over the professions is unacceptable, however, surely specific criteria should be prescribed for FTC use in applying antitrust standards to professional activities.

In testimony before the House Subcommittee on Commerce, Transportation and Tourism on April 20, 1982, a group of professional design organizations -- the National Society of Professional Engineers, the American Society of Civil Engineers, the American Institute of Architects and the American Consulting Engineers Council -- made the following recommendations.

* See, e.g., 40 U.S.C. Section 541-44.

First, amend the Federal Trade Commission Act to require that, when interpreting a professional standard or practice under the act, the FTC must weigh on the record the over-all social utility and value of the questioned standard or practice against any alleged anticompetitive effects. Such standards or practices may not be struck down without clear evidence that they are unjustified. This is not a request to shield the professions from liability for anticompetitive practices that lack countervailing social benefits. Instead, it is merely a request that, before imposing such liability, the FTC be required to consider the public interest involved. In reality, this is no more than it should be doing before exercising any form of regulatory authority.

Second, the Federal Trade Commission Act should also be amended to make clear that the act is not intended to give the FTC authority to preempt state legislative or administrative standards regulating the professions. The professional design groups maintain that this is the intent of current law and point out that this interpretation is consistent with Supreme Court antitrust decisions dating back to 1943.*

The FTC, however, apparently thinks it should regulate the states. In a recent rulemaking proceeding, the FTC attempted to impose a preemption of numerous state laws.** And in its

* Parker v. Brown, 317 U.S. 341 (1943).

** American Optometric Association v. FTC, 626 F. 2d 896, 910 (D.C. Cir. 1980).

so-called "occupational deregulation inquiries", the FTC signaled its willingness to usurp the states' traditional role in regulating professional practices and indicated that it believes state "deregulation" to be the proper approach to professional services.

The United States Supreme Court has consistently recognized the authority of the states to regulate the professions:

We recognize that the states have a compelling interest in the practice of professions within their boundaries, and that as part of their power to protect the public health, safety, and other valid interests they have broad power to establish standards for licensing practitioners and regulating the practice of professions.*

The professional design groups believe the FTC has neither the authority nor the expertise to decide what regulations are appropriate to ensure quality of services in the professions. We therefore believe it appropriate to amend the act specifically to so provide.

Mr. Chairman, I hope the issues I have discussed -- A-E service procurement, working relationships, liability and regulation -- serve to illustrate the dangers that stressing price as a determining factor in contract negotiations can have for building safety and structural failure. A wise man once said, "The bitter taste of poor quality remains long after the sweet smell of low price is gone". I hope this perspective will be useful to the Subcommittee throughout its analysis of building safety.

This concludes my statement. I will be glad to respond to any questions you may have.

Thank you again for the opportunity to appear before this Subcommittee.

* Goldfarb v. Virginia State Bar, 421 U.S. 773, 792 (1975).

Mr. GORE. Well, thank you.

I assure you we are going to do an in-depth study of this entire problem and make every effort to achieve some goal alinement among the various professional organizations involved.

I thought we would hear from the last witness on the panel before questions.

Dr. Richard Wright, Director of the Center for Building Technology, National Bureau of Standards.

Dr. Wright, we welcome you to proceed.

Dr. WRIGHT. Thank you, Mr. Chairman.

As you suggest, I will briefly summarize our written statement that has been submitted for the record.

Mr. GORE. Good.

Dr. WRIGHT. Dr. Pfrang and I are pleased to be here to discuss the technical causes for structural failures and the means to mitigate them and to participate with our distinguished colleagues here in the discussions of the panel.

I want to comment briefly before the panel discussion begins on five major factors.

One, the role of the National Bureau of Standards in the building community, essentially the reason that we are here today.

Two, the nature of our structural engineering program at NBS, so that you understand the technical background that we bring to this discussion.

Three, insights that we have gained through investigations of disasters and structural failures as to the underlying physical causes of structural failures.

Four, a brief discussion of the Federal authorities related to the occurrence, investigation, mitigation of structural failures.

Five, some comments on requirements for failure investigation based on the experience that we have had and discussions that we have had on the subject.

The National Bureau of Standards is the Nation's central physical sciences and engineering measurements laboratory. We have no role in the promulgation or enforcement of structural standards or codes, or any type of building standards or codes, but we do provide technical support for the organizations that do develop these. Usually there are voluntary private sector organizations.

The studies that we make that allow definition of the various characteristics of structural performance and provide means to evaluate these characteristics in advance during the design stage, and to test for them during the construction stage or during the occupancy stage. This is the subject of our work.

We feel it is important that the Bureau of Standards support the building community through this program.

As you are probably aware, buildings amount to about half the Nation's wealth, half of the wealth that we own is invested in constructed facilities. In a normal year, 10 percent of the gross national product will go to the production of new buildings and other constructed facilities. So these are a very important part of the Nation's capital investment and very important part of the economy. It is appropriate for the Bureau of Standards to provide technical support for this big but diverse and disaggregated community.

The programs of the Bureau of Standards related to our subject today include all of our fire research and building technology programs because, as Mr. Cooper and Mr. Sandberg have pointed out, we can't isolate the structural system. All elements of the building will impinge upon the structural system performance. We have in the area of building technology and fire research related to structures a program of \$22 million per year. About half of this is done on a reimbursable basis for other Federal agencies that have building programmatic responsibilities. We provide measurement technology support for these agencies just as we do for the private sector.

Our staff amounts to about 150 professionals including research engineers, and physical scientists and related disciplines.

In the structural engineering program at NBS we conduct analytical, lab and field research to provide technical bases for structural performance criteria and test methods to ascertain how much of these qualities are delivered. The staff amounts to 25 professionals, including structural and geotechnical engineers. The research deals with the understanding of structural loadings, the understanding of structural response and failure mechanisms, the characterization and prediction of structural reliability and the development of test methods, destructive and nondestructive.

We conduct failure investigations and post disaster investigations as part of our program. These provide a unique opportunity to learn about structural performance from a type of a full-scale test that you can't possibly afford to run in a laboratory. These also allow assessment of the adequacy of design and construction practices. We share these results with the whole building community so that the architects, the civil engineers and other groups can identify when it is time to address the improvement of practices. You will find in attachment A to our testimony a citation of the reports that we have issued on disaster and failure investigations.

I would point out that these are all fully available to the public. You will find in attachment B summaries of the reports of recent research in the structural engineering area to give an idea of the topics that we are pursuing in the interest of making structures safer and more economical.

In discussing causes of structural failures, I think it worthy of mentioning two distinct types. A functional failure occurs when a structure does not directly change its load resistance capacity but is in some way unsuited for its intended function. Some of these can be such obvious things as having a column in the wrong place so that you can't use the space as you had intended to use it. This is a functional failure that was overlooked in the process of designing the building. Some functional failures come about from corrosion, from too quick deterioration in the structural properties and from excessive motions or vibrations. If a building moves so much in the wind that the occupants get seasick or tend to evacuate it on windy days, this is an example of a functional failure.

The type of failure I think that most concerns the subcommittee this morning is the collapse, when the structure under load comes apart or undergoes large permanent deformations and loses its load resisting capacity.

These involve great hazards to life and property, particularly for the structures of large public facilities.

If we look at the causes that we have seen for this type of failure, one common cause—and when I say common, it is common for a relatively rare event because really structural failures are relatively rare events—among those that do occur is underestimated loads, particularly earthquake and wind loads and changes in occupancy that can lead to loads much larger than were considered in design.

There also can be extraordinary loads that the designer did not intend to consider. An example of this is tornado winds that are deliberately not considered for most buildings because their frequency is too low, and blast loadings because we don't normally consider that buildings will be attacked by terrorists or that the United States will be subjected to war.

Another major cause of collapses that do occur is the lack of systematic attention to achieving the necessary resistance. This often shows up in inadequate connections where the pieces simply aren't connected well enough and sometimes from unforeseen instabilities of members.

Incidentally, most collapses occur during construction, a topic that, again, is not the direct subject of this hearing today, because construction is the first loading the structure sees and if there is a weakness, construction loads are likely to find it. And in many instances, construction loads are the largest loads that the structure sees in its history. This, of course, is fortunate in terms of safety for the public that the structure to some extent has been proven before it goes into service.

Our experience suggests that collapse is rare when building standards are fully met in design and construction. This is not to say that the building standards and codes are perfect today. There are many areas in which they could be made more economical. They could be made more conducive to acceptance of desirable innovations but, generally speaking, when the standards are met the structure is safe. Of course, competent professional attention is needed throughout the building process to keep failure risks adequately small.

I would comment that it is extremely important that we learn from failures. When structural failures do occur the information as to what was the cause should be widely available to the profession so that those responsible for design and construction are alert to unfortunate things that may occur and can avoid their repetition.

I would also comment that by clever design, as Mr. Sandberg mentioned, it is possible to promote fail-safe structures, structures which if they are overloaded or if there is some unforeseen deficiency, would tend to respond in a benign fashion by undergoing large deflections but without losing their load-carrying capacity. This way the occupants can be warned that something is wrong and get out before there is severe loss of life and property.

In terms of Federal authorities for structural safety there is a very limited Federal authority because public safety in buildings is primarily a State responsibility and often delegated by the States to the local governments. The direct Federal Government role is limited to Federal facilities and to certain limited areas of Federal

regulatory responsibility. I think our experience of very good structural performance in general shows that State and local governments do provide good measures for structural safety. Incidentally, they also have the authority to assure that when failures do occur the causes are investigated and the results are made public.

In terms of requirements for failure investigations we feel that the following things are most important to be sure that the professions and the building community can learn from a failure and avoid the repetition of it.

There needs to be a prompt and complete investigation recording the causes of failure. This means that the authorities that can authorize an investigation and provide access to the data should do so.

There needs to be a prompt reconnaissance when a failure occurs. That means a small expert team needs to get to the site promptly because much of the evidence that will point out the causes of failure is likely to be lost during rescue operations or during cleanup operations.

Mr. WINN. May I interrupt right there, Mr. Chairman?

Mr. GORE. Yes. Mr. Winn.

Mr. WINN. Regarding the Hyatt Regency in Kansas City, did not a request come into your office for an inspection team to come out there?

Dr. WRIGHT. Yes, it did.

Mr. WINN. And did you not go out there and were refused admittance to the hotel at the time?

Dr. WRIGHT. Let Dr. Pfrang respond to that because he was directly involved in that team and it is a complex answer.

Dr. PFRANG. Yes; initially we were denied access to the atrium area of the Hyatt Regency. However, in a few days that was resolved.

Mr. WINN. Who made the request ?

Dr. PFRANG. The mayor's office made the request for us to obtain access.

Mr. WINN. And who said you couldn't come in? Were there still rescue operations going on at that time?

Dr. PFRANG. No, this was well after the rescue phase had been completed but this, I believe, was the result of advice that was given by legal counsel to the owners of the building.

Mr. WINN. You brought up the point of investigation and I wondered why you couldn't get in there. I was aware that you couldn't get in but I never did hear why.

Dr. WRIGHT. There is one other activity that is very important to the team. This is that a thorough investigation of the cause of the structural failure is expensive. The reconnaissance team can identify quickly whether there is something important to be learned from conducting a detailed investigation of the failure.

We would also suggest the use of an advisory council drawn up of experts of the private sector representative of the elements of the building community and of all parts of the country. An advisory council can be above the immediate concerns of those directly associated with the failure and can advise on the public importance and on the prospective technical importance of the failure. We

think it is important not to overdo failure investigations but it is important to do the proper ones.

Finally, the investigating organization should be expert in investigations and independent so that the findings will be credible to the whole building community.

Mr. Chairman, we thank you for the opportunity to be present, we look forward to the opportunity to participate with the panel and we will respond to your questions .

Mr. GORE. Well, thank you very much.

[The prepared statement of Dr. Wright follows:]

STATEMENT OF
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DIRECTOR
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AND
DR. EDWARD O. PFRANG
CHIEF, STRUCTURES DIVISION
CENTER FOR BUILDING TECHNOLOGY
NATIONAL ENGINEERING LABORATORY
NATIONAL BUREAU OF STANDARDS
BEFORE THE
SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT
COMMITTEE ON SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES
August 3, 1982

INTRODUCTION

Mr. Chairman and members of the Subcommittee: Dr. Pfrang and I are pleased to be here today to discuss technical causes for structural failures and means to mitigate them. I request that our written statement be included in the record, as if read, and that I be permitted to make a brief oral summary. Dr. Pfrang and I will be pleased to participate in the discussion of the Panel.

In our testimony we will discuss the following topics:

- o The Role of NBS in the Building Community
- o Structural Engineering at NBS
- o Causes of Structural Failures

- o Federal Authorities Related to Structural Failures
- o Requirements for Structural Failures Investigations

THE ROLE OF NBS IN THE BUILDING COMMUNITY

Research related to understanding the causes of structural failures and providing cost effective means to mitigate them is an integral part of the National Bureau of Standards (NBS) programs in building technology and fire research. This integration is important because structural system performance affects and is affected by all systems of the building and by all participants in the building process from initial planning through design and construction to use and maintenance.

Nearly half of the nation's wealth is invested in buildings that shelter and support human activities. Building construction is the single largest industry in the United States, employing over four million workers. Normally new construction represents more than ten percent of the U. S. gross national product.

The building community is composed of a wide variety of groups: manufacturers, design professionals (engineers and architects), financiers, building contractors, educational institutions, research and testing laboratories, standards-writing groups, labor organizations, Federal and State agencies with building programs, Federal/State and local regulatory authorities responsible for the health and safety of building occupants, and building owners and users. The building community is nationally significant because of its major role in the economy and its impact upon citizens through the residential, institutional, commercial and recreational building environments in which they live, work and play.

The building community is highly fragmented and decentralized, consisting mostly of small organizations with no one group dominating the building process. NBS, as the Nation's central physical sciences and engineering measurements laboratory, conducts building technology and fire research programs which provide knowledge needed by all of the sectors of the building community to realize the benefits of better building performance.

The building process involves many participants including design professionals, building trades, contractors, building product manufacturers and distributors, owners and users. None of these groups has the resources to commit to non-proprietary multi-disciplinary research efforts that are required to achieve better building performance.

Enabling authority for NBS's building research program is contained in the NBS Organic Act (15 U.S.C. 271 et seq.). This Act among other things authorizes:

- o "cooperation with other governmental agencies and with private organizations in the establishment of standard practices, incorporated in codes and specifications",
- o "the determination of properties of building materials and structural elements, and encouragement of their standardization and most effective use", and
- o "Advisory service to Government agencies on scientific and technical problems."

Under this authority NBS carried out studies on the properties of building materials. These studies were expanded in 1921 to include scientific,

technical, and economic research in building; simplification and standardization of building materials; and assistance in the revision of State and municipal building codes. Section 18 of the Federal Fire Prevention and Control Act of 1974 (15 U.S.C. 278f) amended the NBS Organic Act to establish the NBS Center for Fire Research to perform and support research on all aspects of fire and to develop scientific and technical knowledge applicable to the prevention and control of fires.

Specific NBS technical activities include research, technical problem solving, development of technical data, technical policy assistance to decision makers in Federal, State and local government and participation in the work of standards developing organizations. The activities are conducted in cooperation with industry, professional organizations, standards organizations, model building code organizations, university researchers, the National Academies of Science and Engineering, other Federal agencies, and many other groups. NBS participates in international organizations concerned with building and fire research to assure that research efforts are coordinated and that the world's knowledge base is available for the improvement of U. S. building practices. These activities provide the new knowledge required for response to national needs in the development of improved building practices and their implementation in the building community.

The results of NBS work are used in decision making throughout the entire building process. Owners and designers use NBS technology to define the qualities desired in a building. Designers and regulators apply specifications derived from NBS performance criteria in determining the qualities of the building. Designers, regulators, and testing laboratories employ measurement

technology developed by NBS in assessing the compliance of the building with the design specifications. Owners, occupants, users, developers, contractors, labor, financiers, and manufacturers look to NBS performance criteria and the supporting measurement technology for assurance of building qualities consistent with secure investments and the safety, health and welfare of the occupants and users.

NBS does not promulgate or set building codes, standards, specifications or measurement, test and evaluation methods. It provides an objective source of technical information for national consensus standards organizations such as the American National Standards Institute; the American Society for Testing and Materials; National Fire Protection Association; the American Society of Civil Engineers, etc. Close cooperative work with the National Conference of States on Building Codes and Standards, the model code organizations of building officials, and the National Institute of Building Sciences, leads to standard practices that meet the needs of the regulatory authorities of State and local governments. Research providing the knowledge for these standard practices is conducted in cooperation with university and industry research laboratories.

The NBS programs in building and fire research amount to about \$22 million annually with more than half the work conducted on a reimbursable basis for other Federal agencies. The professional staff for these programs consists of about 150 persons including structural, materials, mechanical, geotechnical, chemical and electrical engineers, physicists, chemists, architects, and environmental psychologists. NBS mathematicians, economists, and materials scientists also participate in the programs.

STRUCTURAL ENGINEERING AT NBS

Structural engineering research at NBS provides knowledge required for the development of structural performance criteria and test methods. The implementation of these will lead to safer and more economical buildings. This work includes laboratory, field and analytical research carried out by approximately twenty-five professional staff members, guest workers and post-doctoral fellows. In addition to structural engineering, other specialties include geotechnical, earthquake and wind engineering. Many of the problems addressed as part of NBS structural research activities are highly interdisciplinary in nature and require expertise in areas such as applied mathematics, fracture mechanics and analytical chemistry. NBS is unique among research establishments in its ability to provide the broad range of expertise needed to address such problems. Well-equipped laboratories are available for structural testing and geotechnical studies.

Geotechnical activities include research into soil stabilization, the design and construction of foundations, and the safety of excavations. Construction research is developing analytical models for the prediction of construction loads and their effects during the construction process. Nondestructive evaluation procedures for estimating early strength of concrete and criteria for formwork removal are expected to substantially reduce the number of fatalities and injuries suffered by construction workers while making possible an increase in productivity through innovative and more efficient construction methods.

Central to the improvement of building codes and standards is research into loads on buildings in service and the response of buildings to those loads. Included are loads due to self-weight, occupancy and extreme environmental

effects such as earthquake, wind and snow. Models are being developed for predicting the time-dependent response (acceleration, velocity, displacement and stress) of building structures with full-scale observations providing the basis for model validation. The application of reliability theory in the development of serviceability and safety criteria is a most important element of the Structures Division's current research thrust. When implemented by building codes and standards, these design criteria will allow for consistent levels of reliability against structural failure and inserviceability for all construction materials and construction technologies.

Extreme events such as hurricanes and earthquakes produce "once in a lifetime" loadings for which structures should be designed. Investigations of these full scale load tests provide information on structural behavior and failure mechanisms that cannot be obtained in laboratory studies. The structural performance observed provides valuable information on the adequacy of current codes and standards. These investigations are also of considerable value in establishing research priorities. Attachment A to this testimony is a list of extreme wind and earthquake investigations conducted by NBS either alone or in collaboration with other research establishments.

NBS has conducted a number of indepth investigations of building failures due to other causes at the request of responsible local governments or Federal agencies. These also are listed in Attachment A. Failure investigations tend to be more sharply focused than those associated with natural disasters. Usually a rigorous analysis of the loads and structural response is required to establish the probable cause of failure. The publication of these reports has assured that practitioners and students can understand causes of failures

to avoid their repetition, and that needs for research and improvement of practices are identified and made public.

Attachment B is a list of NBS structural research activities currently underway which will provide technical bases for structural performance criteria and test methods for safer and more economical buildings.

CAUSES OF STRUCTURAL FAILURES

Buildings and other man-made structures can experience two forms of structurally-related failure. One is functional failure in which the structure maintains its overall integrity, but lacks the capacity to perform one or more of its intended functions. The second is collapse, in which part or all of the structure comes apart or undergoes large permanent deformation due to its inability to resist load.

There are many more functional failures than collapses. Examples of functional failures are early deterioration of parking structures from penetration of deicing salts, leaking of roof structures from thermal movements, and vibration of long-span floors causing adverse occupant reactions. Functional failures usually fall into groups repeating themselves in classes of structures, (e.g., deterioration of parking structures). Functional failures result from many causes. However, they most frequently occur following the introduction of a new technology or the modified use of an existing technology. For example, the wide spread deterioration of parking structure, which is currently being experienced, is the result of the introduction of deicing salts as a mean of snow and ice removal. Lightweight long-span flooring systems have been found to perform only marginally satisfactorily as the result of excessive vibration

in use. Functional failures normally do not constitute a hazard to human life, although if remedial action is not taken they can and sometimes do lead to collapse. Fortunately, functional failures are usually amenable to remedial action. However, these fixes are often expensive and sometimes must be repeated. Since they are primarily an economic loss, market place forces generally lead to their eventual elimination.

Structural collapse, unfortunately, has very high potential for loss of human life and injury. For example, the structural collapses associated with a major earthquake or the collapse of a structure used for public assembly can take thousands of lives and cause large numbers of injuries.

Structural collapse takes place when the loads on a structure exceed its capacity to resist those loads. Collapse can be initiated as the result of either excessive loads or deficient capacity (compared to a design or code requirement) or a combination thereof. Generally, structural collapses are associated either with extreme events or design and/or construction errors. The forces resulting from extreme events such as earthquakes and strong winds are often underestimated. Also designers and constructors may fail to provide for the resistance of these forces in a systematic manner. Aside from collapses associated with extreme events, errors in design and/or construction can also lead to collapse. Most often these involve the failure to properly design or construct critical structural connections. Many more error-related structural collapses take place during construction than during occupancy since construction loads arise first and are often higher than those encountered during normal occupancy.

One of the principal functions of building codes and standards is to set down design and construction requirements which will result in safe buildings, that is, buildings with an adequately small risk of collapse. Generally speaking, building codes do an excellent job in this respect. However, for certain sections of the country they may not call for sufficiently high design loads so as to assure safety under extreme events such as earthquakes and strong winds. Furthermore, although codes can call attention to certain pitfalls which may result in mistakes they cannot eliminate the potential for mistakes which may cause collapse. Only a professional understanding of structural loading and behavior can assure the systematic and cost effective provision of the resistance required to safely accomodate loads.

Investigations of structural collapses show that they usually result from improper application of existing technology rather than from inadequacy of existing technology. Building codes and standards generally reflect conservative use of traditional technologies and, when conscientiously followed, usually assure structural reliability. Building codes and standards may, through limitations in technology, restrict some potentially economical uses of innovative structural systems and materials.

Statistical information concerning the frequency and nature of structural failures is not readily available. Functional failures are rarely reported and only the more spectacular of the collapses are reported. Thus, it is difficult to ascertain whether the United States is currently undergoing an increase in the frequency of failures or whether those that are taking place are getting more attention.

The American Institute of Architects recently has completed a study on long-span buildings and, although it has reached no conclusion regarding the frequency of structural collapse, it does note that the potential for loss from these collapses is so great as to warrant special attention by the building community.

FEDERAL AUTHORITIES RELATED TO STRUCTURAL FAILURES

Each State government is responsible for the public health, safety and welfare in buildings, other than Federal facilities, that are located in the State. The building regulatory authorities of State and local governments administer this responsibility. Investigations of structural failures can be and have been conducted under the authorities of State and local governments. Means to minimize these failures can be and have been implemented by the State and local governments.

As described below, NBS has been effective in the investigation of structural failures when its technical assistance has been needed and requested by State and local governments or by Federal agencies with programmatic responsibilities relevant to a specific disaster or failure. The knowledge gained through these investigations and follow up research has been implemented effectively to minimize future failures by NBS's submittal of its findings to the design and construction professions, voluntary standards organizations, model building codes and the regulatory authorities of State and local governments.

REQUIREMENTS FOR STRUCTURAL FAILURE INVESTIGATIONS

Structural failures include: (1) collapses, for which part or all of the structure comes apart or undergoes large permanent deformation, with attendant hazards to human lives, and (2) functional failures, for which the structure

maintains physical integrity but lacks the capacity to perform one or more intended functions. A failure investigation should be conducted and publicly reported when a structural failure is of potentially large public importance, because of actual or potential life and/or property loss, or of potentially large technical importance, because the mechanisms of failure are not well understood.

A publicly reported, sound, well-documented assessment of the causes of failure and the lessons learned will: educate practitioners and students to preclude repetition of the causes, define needs to improve building practices and define needs for research when knowledge is inadequate for the improvement of building practices.

Our experiences in the failure investigations listed in Attachment A show the following requirements for maximum effectiveness of failure investigations:

- (1) Authority to investigate and access to data--which are available from the regulatory authorities of State and local governments for private buildings of human occupancy or from appropriate Federal agencies for federally owned or regulated facilities.
- (2) Reconnaissance - prompt access by a skilled, trained team to gather ephemeral data (that may be destroyed by rescue or clean up efforts) and assess whether there are technical needs for an indepth investigation.
- (3) Advisory Council - made up of persons expert in the technical and public policy implications of structural failures to weigh the potential costs and benefits of an indepth investigation and recommend

whether or not to conduct it. The Advisory Council should include representation of regional, private sector and public interests to assure a balanced perspective.

- (4) Investigating Organization - with financial, laboratory and intellectual resources to conduct the investigation promptly and well, independence to report without censorship or suppression, and continuity to increase its investigatory effectiveness through institutional memory, and its effectiveness in disseminating findings.

This concludes our formal statement. Dr. Pfrang and I would be pleased to answer any questions the subcommittee may have.

ATTACHMENT A*

WIND/HURRICANE/TORNADO DAMAGE INVESTIGATIONS

- Documented damage caused by the 1969 Hurricane Camille, one of the most intense tropical storms to hit the U.S. Mainland.

Dijkers, R. D., Marshall, R. D., and Thom, H., TN 569, "Hurricane Camille - August 1969," March 1971 (NBS, NOAA, OCD).

- Conducted a survey of damage due to several severe tornados.

Somes, N. F., Dijkers, R. D., and Boone, T. H., TN 558, "Lubbock Tornado: A Survey of Building Damage in an Urban Area," March 1971 (NBS).

Mehta, K. C., McDonald, J. R., Marshall, R. D., Abernathy, J. J., and Boggs, D., "The Kalamazoo Tornado of May 13, 1980," Committee on Natural Disasters, National Research Council, July 1981.

- Provided assistance to the Australian government on determining causes of damage due to Cyclone Tracy and assisted in developing reconstruction recommendations.

Marshall, R. D., BSS 86, "Engineering Aspects of Cyclone Tracy, Darwin, Australia, 1974," June 1976 (NBS).

- Conducted an investigation of damage caused in Washington, D.C. area in April 1975 due to severe winds.

Yokel, F. Y., et al., TN 909, "Investigation of Wind Damage in the Metropolitan Washington, D.C. Area, April 3-4, 1975," May 1976 (NBS, DC PA).

EARTHQUAKE INVESTIGATIONS

- Briefed House Committee on Public Works on the damage caused by the San Fernando Earthquake of February 9, 1971 and documented building performance (OEP, DoD, NBS).

Lew, H. S., Dijkers, R. D., Leyendecker, E. V., Pfrang, E. O., and Kramer, S., NBSIR-10556, "The San Fernando California Earthquake of February 9, 1971," 1971.

Lew, H. S., Leyendecker, E. V., and Dijkers, R. D., BSS-40, "Engineering Aspects of the 1971 San Fernando Earthquake," 1971.

* Organizations providing funding for each activity are indicated in parenthesis.

- Made recommendations to the Nicaraguan government for the repair of severely damaged buildings. Conducted investigation at the request of the State Department of building damage caused by the 1972 Managua Earthquake (USAID, NBS).

Wright, R. N. and Kramer, S., TN 807, "Building Performance in the 1972 Managua Earthquake," 1973.

- Conducted an investigation at the request of the state Department of building damage cause by the March 4, 1977 Romania Earthquake. Made recommendations to the State Department for the expenditure of U. S. funds provided to Romania for reconstruction following the earthquake.

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ATTACHMENT B

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Mr. GORE. Mr. Winn?

Mr. WINN. Thank you, Mr. Chairman.

Your statements are very good. I think the differences in your statements point out part of the basic problem that we have in all of these groups of experts going there own way and indirectly several of you referred to lack of authority or restricted authority.

I don't remember any of you talking about really what seems to me to be one of the main problems and that is the lack of communications between the individual people and organizations on the job.

The architect, the builder or the contractor, the structural engineer, the city or local inspector, whoever has the authority in that jurisdiction. Maybe that is one of the real problems? Certainly in some cases it works. It works very well most of the time.

In other cases maybe you are just lucky that even though they haven't communicated too well that things fell together and everything was OK.

Dr. Wright, what jurisdiction would you give your advisory council? Would you make them the top jurisdiction in the United States?

Dr. WRIGHT. This advisory council that I mentioned would not have anything like a regulatory responsibility.

Mr. WINN. Would it be educational?

Dr. WRIGHT. It would deal only with the issue of when is a detailed failure investigation in the public interest.

Mr. WINN. But then wouldn't the same thing result there as did in the Hyatt Regency, the legal aspects might take over and, of course, many people would what to use the advisory council, as some lawyers would want to use it for their parochial interests?

Dr. WRIGHT. The legal authority to conduct the investigation would have to come from the State or local government with responsibility for public safety in the area. That would be the legal authority.

The advisory council would deal only with the conduct of the technical investigation.

Mr. WINN. Well, then, would an impartial Federal board such as the National Transportation Safety Board which could investigate structural failures in a factfinding manner without assessment of a liability, would that be helpful to have such a thing like that?

I am certainly not one to try to get the Federal Government involved.

Dr. WRIGHT. I find it difficult myself to make a parallel between building structures failures and the National Transportation Safety Board.

Because, as I understand it, and I am not an expert on transportation law, but as I understand it, there is a Federal regulatory responsibility and there is no counterpart for the type of structures that we discuss today.

That is why I can't make the association between the National Transportation and Safety Board and some sort of Federal structural investigation.

Mr. WINN. I think the next question has to be then, where do we go? Who do we go to? Some people go to the Bureau of Standards.

Some people go to the various code groups that Mr. Cooper referred to. Where do we go?

How are we going to improve the situation?

Dr. WRIGHT. We have at the Bureau of Standards some expertise on how to conduct the failure investigation, the structures in other facilities but not the sort of expertise to answer the sort of question that you addressed.

Perhaps other members of the panel could address that.

Mr. WINN. I was also going to ask a question about specifications which give a builder certain options; that is, choices of using one material or another when I was building, and I might point out that was 17 years ago, and I know there have been a lot of changes, particularly in materials. We had, in many cases in the specifications, the expression "either/or."

To make it very simple, you could say, in a bathroom in a house, you could use either American Standard fixtures or some of the other brand names that would be comparative. That is pretty prevalent still in the construction industry, is it not, Mr. Cooper? I mean in the design stage.

Mr. COOPER. Congressman, my information is, the firms in my area do just that. In a competitive bidding situation we will specify three or more manufacturers of an item and a contractor is generally permitted to bid any one of those three.

If the contractor wishes to make a substitution of an item he has to submit that item to us 5 days before the date that the bid is due. That request for substitution plus a representation from the manufacturer that that substitution meets in all respects the product that was initially specified or tells us how it does not must be submitted.

If we decide to accept that as an acceptable substitution, we can issue an addendum to all contractors which tells them that they can bid on that item as well. That typically is the way we do it.

Mr. WINN. OK, I understand that.

What happens when you get into the strength tests on cables, on bolts, on reinforcing rods or anything of that type?

Mr. COOPER. Subject to more expert testimony from Mr. Sandberg on that, I will tell you what I know.

Mr. WINN. Well, if you would answer it and then we will have Mr. Sandberg answer it.

Mr. COOPER. All right.

It is my experience that typically we will call for tests in the area of structural steel, reinforcing steel.

Mr. WINN. Thank you, Mr. Cooper.

Mr. GORE. Could I ask you to hold up just a second. We have a record vote in committee. This time maybe you will believe me when I say 3 minutes. We will be right back.

[Brief recess.]

Mr. GORE. The subcommittee will come back to order.

I am sorry for the delay. We had three votes instead of one and a little debate in between.

Dr. Wright, you said that information on failures should be openly available to the public and the results of investigations should be available to the professional organizations.

Isn't it a fact that in many cases when failures occur settlements are arrived at under conditions that preclude the right of the public and the right of the professional organizations to examine the causes of structural failures?

Dr. WRIGHT. Yes, that is true.

Mr. GORE. Well, that is a terrible result in terms of public policy, isn't it?

Dr. WRIGHT. It keeps away from the whole engineering architectural and building community information that would be very helpful in avoiding the repetition of those failures.

Mr. GORE. Well, how could we prevent that?

Dr. WRIGHT. Well, I think if we are dealing with the type of failure that involves hazard to the public that the authority already exists because the State and local governments have authority for the public safety.

I think they could exercise it in order to assure that a public investigation would be carried out.

Mr. GORE. Let's take the example of the John Hancock Building in Boston. Are any of our witnesses familiar with that sequence of events? That is where the glass fell out onto the street and it cost, I don't know how many tens of millions, to fix it?

But, obviously, that is the kind of thing that you don't want to happen again if it could be avoided. But according to information developed by the subcommittee staff, the reasons behind that failure are now under lock and key and nobody can pierce the legal veil that has been draped over the reasons for that failure.

Are you saying, Dr. Wright, that the local officials in Boston or the State officials in Massachusetts could require that that information be made public?

Dr. WRIGHT. I am certainly not commenting here with expertise. I am not a lawyer and I don't know the details of the laws in Boston and in the State of Massachusetts.

Let me express an unexpert opinion and perhaps my colleagues could comment on that.

In that instance you had panels of glass sailing down off that building smashing down into the city streets. There was a great public hazard and it would seem to me that the police powers of the State and local governments were such that they could have insisted on a public investigation.

Mr. GORE. Yes.

Well, it seems to me that when these failures occur we ought to make every effort to disseminate the information related to the causes of the failures and distribute it widely to the professions involved.

Now, your organization, the National Bureau of Standards and the Center for Building Technology can now investigate the causes of structural failure only when you are invited by other parts of the Federal Government; is that correct?

Dr. WRIGHT. When we are invited by a Federal agency that has an authority to investigate or when we are invited by a State or local government agency that has the authority to investigate.

Mr. GORE. Well, as a result of the testimony that I have already heard in these hearings, it seems to me it would be a good idea to invest the National Bureau of Standards with the legal authority

and the mandate to conduct investigations into major structural failures whenever they occur just as the National Transportation Safety Board is charged with that responsibility when an airliner goes down.

That is a relatively rare occurrence also but it is one of sufficient gravity that the causes should be thoroughly illuminated so that a repetition can be avoided.

But as I understood your testimony, Mr. Cooper, I believe it was your testimony, there is now no central repository for information about major structural failures. So an architect or a consulting engineer who is asked to build a long span structure, say, similar to one that has failed years earlier, has no place to go to get information about prior failures.

Wouldn't it be helpful and I will ask you to respond briefly, both of you, Mr. Cooper and Mr. Sandberg, representing the viewpoints of architects and consulting engineers, wouldn't it be helpful to your professions to have a central repository of information about major structural failures?

Mr. COOPER. Mr. Chairman, without question that would be a help to us. Any type of information that we can garner in preventing these types of tragedies to continue would be of use.

I would carry that one step further and speak not on structural failure alone but on product failure as well. You mentioned the Hancock and I know only what I have read, like you.

But my perception is that there may have been a product failure there.

At one point we in the AIA attempted to establish a mechanism for communicating among the various architects in the country, difficulties that we were having with various products and the causes of these difficulties and were informed that under pain of secondary boycott we can't communicate with one another about those difficulties.

Mr. GORE. What do you mean—secondary boycott?

Mr. COOPER. Well, I am not a lawyer but I am informed, I think reasonably, that for the institute to publish a newsletter stating that such and such a firm has experienced this difficulty or that difficulty with a particular product by a manufacturer could constitute a secondary boycott.

The inability to do that allows every professional, theoretically, to fall into the same trap and we are condemned to our own experiences then for learning.

I think that the establishment of the Engineering Performance Information Center at the University of Maryland is a very fine first step in disseminating information on structural and product failures to the professions and I hope that its operations would be assured.

Mr. GORE. Thank you.

Mr. Sandberg?

Mr. SANDBERG. Yes, we would welcome such an organization. In 1979 we had a big snowstorm in the Chicago area. A number of roofs collapsed. The Structural Engineers Association of Illinois gathered data through its members and held several meetings where we tried to pinpoint the reason for the failures.

It was quite evident that certain types of structures were susceptible to failures, but we were told in no uncertain terms, "Don't say that bar joints are not a suitable type of structure because they are very susceptible to uneven loading." So we did prepare a report and we did publish it. It is available to the general public but a lot of the things that we felt were real good, clear, conclusions we did not dare put into the record. We could only hint at them.

Currently there is a suit against the Association of Mechanical Engineers because writing standard specifications for certain types of pumps wrote the specification in such a way that it precluded the use of a certain manufacturer's pump. He sued the ASME.

I understand the judgement went against the ASME. Mr. Burkholder of the ACEC staff is thoroughly familiar with the case and could explain the intricacies. That, however, is the sort of risk that occurs when you start publishing data that points to weaknesses in a certain product or a certain firm's product. You may have a lot of legal suits hanging over your head.

Mr. GORE. Well, I am going to introduce such legislation. So if you all still like it after you see how it is written, get ready to write some letters because legislation doesn't pass easily.

Let me ask you one more question. I am struck by the role of legal liability in contributing to this problem. We hear from the architect's point of view that architects are advised by their lawyers to relinquish responsibility for supervision as quickly as possible.

We are told by the consulting engineers that they are advised by lawyers and insurers to avoid setting foot on the construction site as quickly as that can be done consistent with the contractual obligations and when going on the construction site wear blinders, to use your phrase. And then, finally, when structural failure occurs, we see that investigators seeking to determine the causes of the failure are initially, at least, denied access to the site of the failure because of concerns, again, about liability.

There must be some remedy for this giving preference to the liability fixation process to the detriment of public safety and avoiding major structural failures.

Do any of you have recommendations on how we can begin to attack that problem? Mr. Sandberg?

Mr. SANDBERG. Well, this probably cannot be legislated by Congress but we have found that if a blanket insurance policy can be written for each project that covers the owner, the contractor, the architect, all of the design professionals, against these shotgun and frivolous suits it relieves our worries and encourages the engineer to be more active in the construction phase.

We find, however, that oftentimes we think we are covered and the architect who we work for thinks we are covered, the insurance company thinks otherwise. In a recent project it turned out the architect was covered and the owner and the contractor were covered, but we were naked.

So we had to defend ourselves, and due to some manipulations by the attorneys we were whipsawed into a settlement although we are certain we had absolutely no responsibility and normally the suit against us would have been dismissed. It cost us \$22,500, but it was pay or defend yourself against not only the plaintiff but the

other defendants as well, the architect, the owner, and the contractor.

Mr. COOPER. Mr. Chairman, may I respond and amplify on that a bit?

Mr. GORE. Yes, Mr. Cooper.

Mr. COOPER. Because I feel that I may not have given you the full picture on field observation, as it applies to design professionals.

The basic services under the AIA contract provides for construction administration of the contract. That is the contract that exists between the general contractor and the owner. The architect under those basic services agrees that he will visit the site periodically and that he will observe the construction process.

During the course of that, his efforts involve checking certain shop drawings with the general contractor or his subcontractor. These drawings are prepared for review by both the architect or the engineer either structural, mechanical, or electrical. Going out into the field and generally seeing that the work is being generally executed is also included.

The architect also generally approves, under these basic services, periodic payments to the general contractor on account of work completed.

At the point in time when the building is ready for beneficial occupancy, a point in time called in the trade "substantial occupancy", the architect and the engineers make a detailed inspection of the building and provide a punch list, a list of items to be completed by the general contractor and once those are done he makes another inspection determining that that is the case.

That is the normal basic observation services provided by design professionals in my experience and it is my experience that under most circumstances architects and engineers do provide that type of service.

There is a more detailed service that can be provided which is full-time project representation. The duties of a full-time resident on the job are outlined in an AIA document which we would like to submit in evidence for you. Owners have the opportunity to avail themselves of that document.

It is my opinion that when the architect or the engineer or any of the design professionals feel that that type of representation is necessary and, I think in my opinion on any structure where there is a lack of redundancy that type of service would be a good thing to provide, the owner can provide that and have the availability of daily full-time representation of a resident engineer at the site representing him, inspecting in detail the activities of the general contractor and the subcontractors.

The question of liability as it relates to the design professional, however, generally involves in the field a question of personal injury and, as you have heard this morning, that is during construction.

Mr. GORE. I understand, Mr. Cooper. What you are saying, in essence, is that there are different organizational arrangements between the architect, the engineer, construction company, and the owner?

Mr. COOPER. Correct.

Mr. GORE. The owner of the building can select and create an organizational arrangement that provides for a single point of responsibility for quality control and supervision throughout the construction process and I take it that that is preferable in the view of all of the participants in the construction enterprise.

However, for a variety of reasons, different legal arrangements are now being used, arrangements that provide for, gray areas in Mr. Sandberg's phrase, when responsibility shifts from one participant in the joint enterprise to another at various stages along the way and in that gray area while responsibility is shifting from one participant to another, things are missed and at some points nobody is really exercising that responsibility and during those times mistakes are made leading to major structural failures.

Now, you are saying two things. First of all, it is preferable to create a legal arrangement that provides for a continuous point of responsibility that is clear.

I am saying in addition to that, that the professions involved need to make certain that whatever the legal arrangement, we don't allow these gray areas to occur when no responsibility is being exercised.

Mr. COOPER. Mr. Chairman, with all due respect, I am trying to say one other thing and that is that the responsibilities for the safety of the design are best overseen by the design professional who created that design and not by some third party such as a construction manager or a general contractor under a design build arrangement and that the owner would do well to recognize at the outset the various relationships that he is creating and what he is giving up when he sets up a specific framework that does not provide for that.

Mr. GORE. That certainly makes sense to me.

Mr. Walker?

Mr. WALKER. Thank you, Mr. Chairman.

It has been mentioned in the course of the hearings today the idea of having some Federal input and oversight into the matter through an organization much like NTSB, the National Transportation Safety Board, when accidents do occur.

My question relates to whether or not that fits the same kind of pattern under which NTSB operates. NTSB does have the ability to make recommendations after their investigation of an airplane crash to FAA which then has certain police powers over the industry in order to implement the recommendations of NTSB.

In other words, there is a direct Federal flow of responsibility here, including certain police powers in the Federal Government that make that kind of scenario valuable in the airline field.

Does that same kind of thing exist in the construction industry that would permit Federal recommendations to be implemented under some kind of police power that would assure some success in implementation?

Dr. WRIGHT. Mr. Walker, as I noted in my testimony, there is no corresponding Federal regulatory role. Nor is there, to my knowledge, any desire for this on the part of the building community so there is a very important difference between the role that you cited for the National Transportation Safety Board and any Federal role you might have for investigations of building failures.

Mr. WALKER. And so we rely upon the police powers of the States, much as it is in the situation today to see to it that any kind of negligent action were properly prosecuted and we would, therefore, also depend upon those States to implement the recommendations that might come out of such a Federal agency.

So, I guess what I am saying is, could we create the kind of confusion by getting into it at the Federal level that would result in not less but more problems of design? Is there a potential for that?

Mr. Cooper?

Mr. COOPER. Mr. Walker, I will answer that by saying that I am sure you could create more confusion.

Mr. WALKER. We have it well within our capacity.

Mr. COOPER. Fundamental to this whole thing is a given and that is most owners do not want to build buildings that are going to fall down. Most architects do not want to be involved with them and most contractors do not want to be involved with them.

If there is a design error or a construction error, most owners would welcome knowing that assuming that it did not prejudice their legal claims against any of the parties involved.

I think most professionals would welcome knowing that and would take steps to correct that. I think that simple information coming from some central agency, some clearinghouse of information would place most architects, even just ordinary people, on notice that there were problems and we would take steps ourselves to correct our own practices.

Mr. WALKER. I guess what I am hearing from you, though, is that the fundamental problem is in the legal liability process which makes it impossible to share data with regard to causes and effects of structural failures.

I gather that is what I am hearing here this morning.

Does the creation of some kind of a Federal clearinghouse get around that problem?

Mr. COOPER. Well, I can't answer that. Certainly I think that it would be better than what we have now, which is discovering the beartraps where they are and being caught in them.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. GORE. Mr. Winn?

Mr. WINN. Thank you, Mr. Chairman.

I told the chairman that I would be interested in working with him on this proposed legislation. We haven't seen any wording or anything, of course.

I am not so much interested in a new governmental regulatory agency type of operation as I am more the clearinghouse idea.

Mr. GORE. Will the gentleman yield?

Mr. WINN. Certainly.

Mr. GORE. That is the central thrust of the idea that I have in mind.

Mr. WINN. All right, fine.

I might ask, don't the structural engineers and the mechanical engineers and people in that field, don't they all belong or have the option of belonging to the association within their own association like in Kansas City they have the builders association which incorporates practically everybody, including the heavy constructors?

Mr. SANDBERG. Yes they do when there are failures, there is dissemination of the problem throughout the professions that are concerned.

However, we don't get the results of professional technical investigations like in the case of the Hartford Civic Center in Connecticut. We just get a little bit of data, until a complete investigation is made and in many cases even then, it's not available to the profession.

So it does get disseminated but it isn't like having material that can be printed. I don't think any of us would print information we heard about the Kansas City Hyatt Regency. We can now start to cite details to avoid. We can disseminate that.

Mr. WINN. Yes, you could do that but at the same time you could also report some of the findings of the various groups involved, at least you could put into print what you think you found wrong and what you think the causes were.

Mr. SANDBERG. There is still a problem. We had the big snow in the Chicago area where a lot of roofs collapsed and we found the predominant failure was in bar joist roofs which led us to conclude that bar joist roofs in an area like Chicago with drifting snow are not the best answer. As a result the bar joist manufacturers really came down on us. So when the report, finally came out, it was pretty well watered down.

Mr. WINN. I understand that. I think that is going to be part of the problem. Still I would have to say, particularly to Mr. Cooper, that your profession, and certainly it is a very admirable and fine organization, AIA, seems to be, these days, suitbound in all of these nuisance suits.

There are probably more now than ever before in history. Of course, that is the direction our courts are taking, too. Many lawyers are asking about that.

Mr. COOPER. We are not suitbound by choice.

Mr. WINN. I understand that.

Do you think you are suitbound because of lack of training in the engineering and architectural schools or is there a weakness there that we ought to go clear back before you fellows even get started into your practices?

Mr. COOPER. Well, the curriculum for architectural study is now 6 years of formal training plus 2 years of internship before one can begin to take the State registration exam.

Mr. WINN. How do they come to the realization or where do they get the background that a bar joist is good or not good for a certain type of support structure?

How do they get the background? How do they get educated along the problems that we are talking about because a lot of them could well be fundamental or functional failures, too?

Mr. COOPER. As a general principle, the architect is, in my view, a generalist in terms of how the building design team is formulated and he relies, in turn, on specialists to actually do the work of structural design. In the case of Mr. Sandberg, for heating, ventilating, electrical design, and soil mechanics.

Mr. WINN. Yes, you have your engineers that you work with that produce designs and you call them in and consult with them while you are turning out the design.

Mr. COOPER. Right.

Even the smallest building, say a commercial building, generally will have at least three engineering disciplines involved with the architect; structural, mechanical, and electrical.

The architect does the drawings for the basic building and its enclosing walls and interiors. The structural engineer does the structural drawings and the other disciplines do their own.

In response to your question, the architect learns that to some extent during his formal education in college but more specifically as he enters an architectural office he is under the guidance and tutelage of more experienced architects.

Mr. WINN. But he has the option of calling those specialists in at any time if he is working on a set of plans?

Mr. COOPER. Without question.

Mr. WINN. Have you given any thought, Mr. Cooper, to any changes that might be necessary in the legal system to reduce these nuisance suits?

Mr. COOPER. Yes, I have.

Mr. WINN. Maybe we ought to have a lawyer here.

Mr. COOPER. Again, I keep saying I am not a lawyer.

Mr. GORE. We have got one in tomorrow's hearing. We didn't have any trouble finding one at all.

Mr. WINN. They were probably lined up.

Mr. COOPER. I think that it is unlikely that this could be accomplished but in the area of property damage as opposed to personal injury, I think that if a plaintiff brings a suit and is not successful that the plaintiff ought to bear the burden of those court costs.

I think that in the area of personal injury that nothing should stop the plaintiff from being able to get to court under any circumstances that he can and the present system works there.

One of the problems that we have, Congressman, is that in construction accidents where you have a workman who is injured during the process of constructing a building, he or his survivors generally are taken care of under workman's compensation.

Mr. WINN. Yes; that is pretty well covered.

Mr. COOPER. Then the fun generally begins because that amount is a fairly nominal amount in my experience, at least in my State. And the plaintiff's lawyer then turns around and sues the design professionals and the owner for huge sums of money.

This is where you begin to see the concern of the design professional in stepping forth on the construction job and saying don't do this, don't do that, don't do the other, because he knows that if there is a construction accident the general contractor is insured but frequently the architect is not.

Mr. WINN. Let's get back to the design professional or the architect.

Isn't it true that the architect can bid a project either with that supervision in there or he can take off 1 or 2 percent? I don't know what the percentages are. He can furnish complete supervision, complete inspection, maybe as much as having a man on the job all the time, or part time, come by from time to time, or he can visit without any of that in there whatsoever.

It is a matter of your bidding procedure, is it not?

Mr. COOPER. It is not only a matter of our contracting procedures, Congressman, it is a matter of yours.

Mr. WINN. Architects try to get away from the word "bidding" because architects are not supposed to bid, but they do. Let's not kid ourselves.

Mr. COOPER. In submitting bids for work I think that most architects have to decide and most engineers have to decide whether or not they are prepared to provide the services only that the owner asks for or to insist that the owner take more.

Mr. WINN. I understand. But if you insist that the owner take more you may lose out because you are one or two points for your supervision.

Mr. COOPER. Either that or you provide those services at no additional cost.

Mr. WINN. That is right. That comes out of your profits.

Mr. COOPER. The Federal Government itself, in my experience, very often contracts with architects and engineers on the basis of providing construction contract administration through their own forces or others.

Mr. WINN. The Federal Government does?

Mr. COOPER. Yes, sir.

Mr. WINN. I have no comment on that.

You know what we are getting into there and I hate to keep referring to the Hyatt Regency but now we have got fantastic class action suits out there and that is new, relatively new to the construction industry.

It has been true in cereals and other things and certain types of sleeping garments and things for kids. But now any accident of the Hyatt Regency type where all the lawyers combine together and file a joint action or a class action, that is a new problem that the construction industry and all of the industries that you fellows are involved with are going to have to face as far as your insurance coverage is concerned.

Mr. COOPER. Speaking for my own part, I am not here today suggesting that when the design professional has made an error that he should be held harmless from answering for that error.

Mr. WINN. I understand that.

Mr. COOPER. I don't know anything about the Hyatt Regency except what I have read so I am not in a position to comment on the class action suits.

But if there were design errors then it would be my view that I would not be seeking relief from those.

Mr. WINN. But, that is the direction they are going. They are suing everybody involved and I don't know how many different people now have been sued.

Let me ask either Mr. Sandberg or Dr. Wright, who I think may have the answer on this. In the collapse of the Kemper Arena, the roof presented an unusual situation. It was a free span building, a very unusual type of architecture and for years that arena had been in operation and they had no problem. Then all of a sudden it collapsed. Thank God there was nobody in there. Basketball teams played there, the hockey team, rodeos, it is usually pretty heavily used but there was no one in the building, when the failure occurred. But after heavy winds I don't know if it has even been de-

clared tornado-type winds, but heavy winds following or along with a heavy rainstorm, put an excessive weight on the structure. The water was not able to run off the roof fast enough. The combined load of wind and water, as I understand it and this I get only from what I have read in the paper, developed sort of a waving motion where the weight itself was about twice what it normally would be with snow on the roof like in Chicago, as you referred to. The point is, how can a designer design for overloads? How are we going to take care of a problem like that because that is an unusual circumstance, but we have those unusual circumstances?

Bridges, I suppose, are the same way when they get waving or too much traffic.

Mr. SANDBERG. Yes, there is the problem of fatigue that we are not yet totally sure how to detail or design to eliminate.

Mr. WINN. So we have a system of unknown technology there.

Mr. SANDBERG. It is developing. In the past we used to have riveted joints. We now find out that those were excellent relieving mechanisms for overstress.

We didn't really appreciate it. Now we are welding. We get things so firmly fixed that we have fatigue problems that we had very seldom in the old days. And what was, 20 years ago, considered a real good detail for welding is now a very big no-no.

Today you never do certain things that you did 20 years ago but some of these problems are just appearing.

Again, with this particular structure, I don't know the full details. But I do believe that this was a problem of fatigue. That is why it could function and withstand a lot of load for a period of time. Then a fatigue crack starts and when all of a sudden a load as you describe is applied, zoom, just like a zipper the crack propagates across the member.

Mr. WINN. Mr. Chairman, I have had more than my share of the time, and I thank you.

Mr. GORE. That is fine.

Mr. WINN. How long are you talking about in fatigue showing up in materials? I mean that building is not very old? I forget how old it is.

Mr. SANDBERG. Yes, it depends on the range of stress and the number of cycle reloadings that will be applied.

Now, if the range or magnitude is large, the member can undergo this stress say 50,000 times before failure. If the range of stress is lower, the member may undergo 2 million cycles. Proper design requires an estimate of the number of cycles so that the member has enough material so the range of stress does not cause a failure in the life of the structure.

We are really getting into this now. We have inspected the Elevated Loop of Chicago with a team of other consultants and found fatigue to be one of the problems there.

Mr. WINN. Do you happen to know if the roof in Kemper Arena in Kansas city, did your group send inspection teams in there to try to analyze what their problem was there?

Dr. WRIGHT. We did not, but Kansas City did engage an independent structural consultant.

Mr. WINN. The city of Kansas City?

Dr. WRIGHT. Yes.

Mr. WINN. And was there information disseminated to you fellows in the field, in the profession?

I can tell by the looks in your faces it obviously wasn't.

Dr. PFRANG. Copies of the report are available. It is not what I would classify as a truly in-depth study of the failure and the distribution has been rather limited. But they can be obtained.

Your question was, I think getting at the point, were we going beyond the state of technology on the Kemper? There is nothing that I have been able to ascertain regarding the collapse of the Kemper which implies that we were at any point beyond our current state of knowledge with regard to that.

Now, also you have talked about heavy loads on it. To the best of my knowledge, and again this is from the skimpy information that is available, the loads that were present both prior to and at the time of collapse did not exceed those values that would be called for through an application of the Kansas City building codes.

Mr. WINN. Well, I think that is true. I don't question that because that building has been there, say, 8 to 10 years, and has had some tremendously heavy snow loads and, as I say, it is a free-standing building. There are very few, if any, columns in the middle. That is typical of the direction that the design profession is going trying to give us indoor stadiums that are covered the same way some football stadiums are where there are no posts in the way so every seat is a good seat. That is fine except you need a big covered dome. Early on in New Orleans they had trouble with the covering itself, several of them had. Now that technology has improved.

I am sure up in Pontiac, Mich., there is not going to be much doubt about they are going to get some real heavy no loads. I know that you are improving but I am trying to figure out in my own mind if in the basic design they could overdesign to take care of that? That is almost an impossible question until you know what your load is or what your problem is.

Dr. PFRANG. The technology does exist so that we can design long span structures such as the Kemper so that they will have a very high level of reliability.

Mr. WINN. And where do these people get that information? Where do these architects? Where do these builders get that information? What do you use for a clearinghouse?

Dr. PFRANG. Several different sources. One source is the national standards which relate to loads and then other national standards which relate to the resistance. For example, in the case of Kemper, there is a steel design standard. In addition to that, the professional has to supplement that in the case of something like the Kemper with technical literature because you are starting to get into a case where you have a highly stressed structure. It is working very hard and in that case you had best stay up to speed on what is coming out in the technical literature. It used a very high strength bolt. That bolt is susceptible to fatigue. That information has been reported in the technical literature.

Mr. WINN. Thank you very much. Thank you, Mr. Chairman, for allocating so much time.

Mr. GORE. Well, thank you.

I found the interchanges very interesting.

We are going to have to move on. Let me ask a couple of questions just briefly and I would ask for short responses.

One of the witnesses mentioned that the reliance on computers to solve problems is bypassing the sort of judgments that people have learned to make on the basis of experience. That it is sometimes lost with overreliance on computer-aided design.

Was that you, Mr. Cooper?

Mr. COOPER. Yes, sir.

Mr. GORE. Is that in the way of advice to younger architects?

Mr. COOPER. No, sir. That was testimony that the long span task force heard.

Mr. GORE. That was developed by the AIA's study panel on long span structures?

Mr. COOPER. That is right.

Mr. GORE. Now, Dr. Wright and Dr. Pfrang, what percentage of structural failures does the NBS investigate on an annual basis, just a tiny fraction?

Dr. WRIGHT. It is a very small fraction. We don't know the total so we can't express it as a percentage but we run on the order of one or two indepth failure investigations per year.

Mr. GORE. I see. And what is the cost of such an investigation typically?

Dr. WRIGHT. This will depend on the complexity of the investigation. Let me turn to Dr. Pfrang to cite some of the recent investigations.

Dr. PFRANG. We are currently conducting an investigation in East Chicago, Ind. on the Riley Road interchange collapse. Our current estimate on the cost of that is \$177,000. Now, the other end of the spectrum is an investigation such as the Kansas City Hyatt which cost us about one-half million dollars to conduct.

Mr. GORE. So we are talking about \$100,000 to \$500,000 per investigation?

Dr. PFRANG. These are rather large investigations that we are talking about. There are other structures that have failed. For an example of a parking structure in Houston, I have heard some figures on what it cost the firm that carried out that investigation for their own purposes and they had done a fairly in-depth investigation. It was not a very complex problem so they were able to do that for about \$20,000 or \$25,000.

Mr. GORE. I see.

I would note for the record that by way of comparison the National Transportation Safety Board's entire budget was \$1.7 million in the current fiscal year with a \$580,000 supplemental. Of course, the universe of major structural failures would be defined by what you mean by major.

Perhaps if you would, you could provide to the subcommittee some estimate of how many major structural failures there are annually so we can get a better idea of what kind of investigative work we are talking about here.

How do you disseminate the information currently from your investigations? Do you just wait for people to ask for it?

Dr. WRIGHT. Our reports are issued publicly, published by the Government. For instance, the Kansas City Hyatt Regency report is available through the Government Printing Office.

Mr. GORE. Do a lot of people ask for it, do you know?

Dr. WRIGHT. We get large numbers of orders. There has been substantial press interest so there have been a number of press conferences held that point out that the investigation has been conducted and that have highlighted principal results so that people can seek the reports.

We publish in the professional literature that Dr. Pfrang mentioned; articles in Civil Engineering magazine that go to all 75,000 members of the American Society of Civil Engineers get out the information on the Willow Island collapse, the Hyatt Regency collapse, the Cocoa Beach collapse in Florida, so these are well disseminated.

Then we work directly with technical committees. Dr. Pfrang is vice chairman of the American Concrete Institute and a member of their committee on design standards for buildings. We have a mechanism to assure that they look at the report results that pertain to concrete structures. We have similar relationships with most of the major national voluntary standards organizations that produce design and construction standards.

There are a variety of mechanisms and we try to use them all in order to get this information out to the community.

Mr. GORE. All right. Very good.

Would you gentlemen be willing to answer additional written questions for the record?

Mr. COOPER. Yes.

Dr. WRIGHT. Yes.

Mr. GORE. We have another panel and your testimony has been so interesting we have really taken too much time with you this morning.

We appreciate your attendance here this morning very much. Thank you all very much.

Mr. SANDBERG. Thank you.

Mr. GORE. Our second and last panel today is made up of Mr. Lloyd Duscha, Chief of the Engineering Division of the U.S. Army Corps of Engineers, and Mr. Vincent Bush, a representative of the Council of American Building Officials here in Washington.

We will have another day of hearings tomorrow. This is our last panel today.

Without objection, the prepared statements of this panel will also be put into the record.

Mr. Bush, you are accompanied by Mr. Kuchicke. And your full name for the reporter.

STATEMENTS OF LLOYD A. DUSCHA, CHIEF, ENGINEERING DIVISION, DIRECTORATE OF CIVIL WORKS, U.S. ARMY CORPS OF ENGINEERS; VINCENT R. BUSH, ASSISTANT TECHNICAL DIRECTOR, INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS, ON BEHALF OF THE COUNCIL OF AMERICAN BUILDING OFFICIALS, ACCOMPANIED BY RICHARD KUCHICKE, EXECUTIVE DIRECTOR, COUNCIL OF AMERICAN BUILDING OFFICIALS

Mr. KUCHNICKE. Richard Kuchnicke, executive director of the Council of American Building Officials.

Mr. GORE. And your first name is what?

Mr. KUCHNICKE. Richard.

Mr. GORE. Mr. Duscha, we would invite you to proceed and if you care to summarize any of your statement, please feel free to do so.

Let me forewarn you that there is a vote on the floor and I may have to interrupt you when the second bell rings.

Please proceed.

Mr. DUSCHA. Thank you, Mr. Chairman, I will summarize.

By way of introduction, I am the Chief, Engineering Division, Directorate of Civil Works, Office of Chief of Engineers, U.S. Army and my present responsibility involves the entire spectrum of water resources structures designed by the U.S. Army Corps of Engineers. I am also designated as the Dam Safety Officer.

During my career with this organization, I have been involved with a wide range of structures, including military facilities, transportation facilities, water impoundment structures, and underground structures.

My statement will touch on some of the factors which can contribute to structural failures, and on some of the practices used within my agency to decrease the potential for failure.

In addressing the subject of structural integrity, I would say at the outset that the main ingredient in assuring sound structural products is the technical capability of the engineers involved.

Such capability encompasses both a thorough educational background and sufficient experience to make sound engineering judgments.

An adequate design review process is also an essential element. In our program, all projects are subjected to varying independent levels of review according to the complexity of a project. These reviews serve to detect computational errors in design, to evaluate the assumptions and judgmental decisions, and to assure completeness in scope and detail.

Engineering design is similar to other professions in that a second opinion may be appropriate, especially if the project is complex and innovative approaches are being tried. One technique is the use of expert consultants. Individuals or teams of consultants with recognized expertise are hired to review and comment on the design performed by others. This technique is especially useful when there are only a few available highly qualified experts in some engineering specialty.

Although the safety of structures rests primarily with the designer, we must recognize that the best design can be compromised by poor construction practices, inadequate surveillance during construction, defective materials, changed conditions, and improper maintenance.

Therefore, it is necessary to develop an organizational structure which not only maintains highly capable technical personnel, but also provides for adequate interfacing during all stages of planning, design, construction, operation and maintenance.

While on the subject of qualified technical personnel, I am obliged to mention that it is becoming increasingly difficult for those engineering organizations in the Federal sector, and presumably the State and local governments as well, to maintain a quality work force. Several factors contribute to this, such as a decrease in challenging opportunities, engineering salaries not being competi-

tive with those in private industry, and the diversion of work to the private sector. This matter of retaining technical capability is of concern to the Corps of Engineers, and we are taking a hard look at the causes of and remedies for improving the situation.

Other influences also contribute toward less reliable engineering works. The demand for least cost construction finds administrators influencing engineers to reduce standards and cut costs of a project. This influence usually stops short of cutting costs to the point where the structure would be obviously unsafe. However, if the designer yields, even slightly, to this sort of influence, the margin of safety diminishes. I certainly do not advocate that engineers be relieved of concern for cost reduction. However, when all reasonable measures have been taken to design a least cost structure that includes acceptable and recognized design standards, further efforts to reduce costs should be abandoned.

One of the major concerns of my organization, and others, is the safety of dams. The Corps of Engineers owns and operates about 500 dams with some 70 under design and construction. This imposes an awesome responsibility and we take that responsibility seriously through a complex system of checks and balances. One of the steps we have taken is to establish dam safety committees in our headquarters and field offices. The major purpose of these committees is to review, periodically, our system of assuring dam safety, to assure proper informational flow on dam safety issues, to modify and establish criteria, and to insure that each cognizant element is discharging its responsibility in an appropriate and timely manner. While we are highly confident of our ability to design and construct dams, we continue to find areas where improvements can be made.

While on the subject of dam safety, I should add that during execution of the national program of inspection of non-Federal dams, we found a large number of States either with inadequate dam safety legislation and standards or inadequate personnel or funding to insure safe dams. The program also surfaced the tendency to neglect maintenance of structures once built, and to ignore the changing environment around the structure which converts a relatively safe structure to a hazardous structure by virtue of the consequences of its failure.

One area of dam design which has required continual justification to those unfamiliar with flood potential is the inflow design flood used to size spillways and establish the tops of dams. Many assume that a relatively short historical record of floods provides an adequate basis for what could occur during the life of a project. This concept has resulted in many dams overtopping and failing from floods larger than the design flood. Also, because of the costs involved, many are reluctant to design dams for these extreme floods.

We have found that a program of periodic inspection and surveillance of completed structures contributes greatly to assuring continued safe service. In addition, it serves as a mechanism helpful for planning and ordering priorities for maintenance activities. The absence of such inspections often can allow alerting symptoms to go unnoticed and deterioration to worsen to such an extent that structural stability and safety are compromised. Qualified person-

nel, experienced in the operating behavior of structures as well as their design, can assess adequacy of performance through the analysis of instrumentation data and the observation of behavior during service. An example I might offer in this regard pertains to seepage which occurs through or beneath water impoundment structures. Such seepage is often considered normal and expected, with a great deal of design attention being given to its control. Knowledge of these seepage patterns, and any changes that may develop as the structure ages, are important factors to be considered in assessing the performance and safety of the structure, and can only be accomplished satisfactorily through regular, postconstruction surveillance.

Mr. GORE. Excuse me, Mr. Duscha, if you would withhold, we have a vote on the floor and it will be about 8 minutes. I am sorry for the inconvenience.

[Brief recess.]

Mr. GORE. The subcommittee will come back to order.

I am sorry for the interruption.

Mr. Duscha, please proceed with your statement.

Mr. DUSCHA. Thank you. I will continue where I left off.

Instrumentation, and the rapidly advancing technology with which it is associated, is widely available in many forms to the engineering community, and has proven to be a necessary element in assessing structural safety and monitoring performance. While reliance must not be placed on instrumentation alone, if its data is competently interpreted and used in concert with a program of inspection and surveillance, it can and has provided valuable insight into internal or subsurface conditions and behavior. Data generated from instrumentation must, however, be reviewed critically by competent design personnel in a timely manner for it to be of value in assuring structural safety.

A factor which I believe to be critical to structural safety is the effective interface between design and construction personnel during the construction process itself; that is, the translation of design intent to construction practice. The best of designs, and the best of construction specifications, can be rendered ineffective and safety compromised, if construction practice is not adapted properly to actual field conditions as they become known. This is particularly true in foundation work, where the best design exploration is the construction itself, which affords an opportunity to confirm "anticipated" conditions and to adjust the design to accommodate "actual" conditions.

To further assist in averting structural failure, particularly in earth structures, recognition must also be given to the potential for latent defects which may be relevant to some structures and their site environment. These are defined as those geologic conditions which exist in nature but whose long-term engineering significance to structural performance is difficult to define. An example of such a defect is foundation cavities in solution susceptible rock formations. This phenomenon must be contended with long after construction and extended periods of successful operation. The proper resolution of such geologically adverse conditions is a thorough and sometimes costly investigation and identification of the potential

for this type of problem by suitably trained and experienced professionals during the design stages of the project.

The continued safe operation and service of a structure is highly dependent upon systematic surveillance of its response to loading throughout its life, and the recognition of design loading being exceeded by changes in use of the facility. Increased truck loading on bridges is a common example.

Design, construction, and operation of safe structure is a complex problem involving an interrelationship of many people. Its success depends on the technical capability and the professional integrity of those involved.

In summary, I would say that engineers must be ever cognizant of their role in protection of the public safety and welfare and not relinquish this responsibility to economic expediency, outside influences, individual benefit, or lack of foresight and self-development.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Duscha follows:]

STATEMENT OF LLOYD A. DUSCHA
CHIEF, ENGINEERING DIVISION
DIRECTORATE OF CIVIL WORKS
U.S. ARMY CORPS OF ENGINEERS

AVERTING STRUCTURAL FAILURES

I am Lloyd A. Duscha, Chief of the Engineering Division, Directorate of Civil Works, U.S. Army Corps of Engineers. By way of introduction, my present responsibility involves the entire spectrum of water resources structures designed by the U.S. Army Corps of Engineers. I am also designated as the Dam Safety Officer. During my career with this organization, I have been involved with a wide range of structures, including military facilities, transportation facilities, water impoundment structures, and underground structures. My statement will touch on some of the factors which can contribute to structural failures, and on some of the practices used within my agency to decrease the potential for failure.

In addressing the subject of structural integrity, I would say at the outset that the main ingredient in assuring sound structural products is the technical capability of the engineers involved. Such capability encompasses both a thorough educational background and sufficient experience to make sound engineering judgments. Faulty engineering judgment can cause or contribute to deficiencies leading to the failure of structures. One example is the acceptance of a computerized analysis of the reaction of structures to loading forces without sufficient empirical validation. Good engineering requires thorough evaluation of all pertinent factors in making decisions which affect the integrity of structures.

An adequate design review process is also an essential element. In our program, all projects are subjected to varying independent levels of review according to the complexity of a project. These serve to detect computational errors in design, to evaluate the assumptions and judgemental decisions, and to assure completeness in scope and detail.

Engineering design is similar to other professions in that a second opinion may be appropriate, especially if the project is complex and innovative approaches are being tried. One technique is the use of expert consultants. Individuals or teams of consultants with recognized expertise are hired to review and comment on the design performed by others. This technique is especially useful when there are only a few available highly qualified experts in some engineering specialty.

Although the safety of structures rests primarily with the designer, we must recognize that the best design can be compromised by poor construction practices, inadequate surveillance during construction, defective materials, changed conditions, and improper maintenance. Therefore, it is necessary to develop an organizational structure which not only maintains highly capable technical personnel, but also provides for adequate interfacing during all stages of planning, design, construction, operation and maintenance.

While on the subject of qualified technical personnel, I am obliged to mention that it is becoming increasingly difficult for those engineering organizations in the Federal sector, and presumably the state and local governments as well, to maintain a quality work force. Several factors contribute to this, such as a decrease in challenging opportunities, engineering salaries not being competitive with those in private industry, and

the diversion of work to the private sector. This matter of retaining technical capability is of concern to the Corps of Engineers, and we are taking a hard look at the causes of and remedies for improving the situation.

Other influences also contribute toward less reliable engineering works. The demand for least cost construction finds administrators influencing engineers to reduce standards and cut costs of a project. This influence usually stops short of cutting costs to the point where the structure would be obviously unsafe. However, if the designer yields, even slightly, to this sort of influence, the margin of safety diminishes. I certainly do not advocate that engineers be relieved of concern for cost reduction. However, when all reasonable measures have been taken to design a least cost structure that includes acceptable and recognized design standards, further efforts to reduce costs should be abandoned.

One of the major concerns of our organization, and others, is the safety of dams. The Corps of Engineers owns and operates about 500 dams with some 70 under design and construction. This imposes an awesome responsibility and we take that responsibility seriously through a complex system of checks and balances. One of the steps we have taken is to establish dam safety committees in our headquarters and field offices. The major purpose of these committees is to review, periodically, our system of assuring dam safety, to assure proper informational flow on dam safety issues, to modify and establish criteria, and to insure that each cognizant element is discharging its responsibility in an appropriate and timely manner. While we are highly confident of our ability to design and construct dams, we continue to find areas where improvements can be made. We assume that safety is an integral part of the design process.

While on the subject of dam safety, I should add that during execution of the National Program of Inspection of Non-Federal Dams, we found a large number of states either with inadequate dam safety legislation or inadequate personnel or funding to insure safe dams. The program also surfaced the tendency to neglect maintenance of structures once built, and to ignore the changing environment around the structure which converts a relatively safe structure to a hazardous structure by virtue of the consequences of failure.

One area of dam design which has required continual justification to those unfamiliar with flood potential is the inflow design flood used to size spillways and establish the tops of dams. Many people assume that relatively short historical records of floods provide an adequate basis for what could occur during the life of a project. This concept has resulted in many dams overtopping and failing from floods larger than the design flood. Also, because of the costs involved, many are reluctant to design dams for these extreme floods. They appear willing to risk the possibility of failure by using a lesser design flood or are not fully aware of the likelihood of the smaller design floods being exceeded. Part of this problem also stems from the lack of rigid standards in some governmental agencies.

We have found that a program of periodic inspection and surveillance of completed structures contributes greatly to assuring continued safe service. In addition, it serves as a mechanism helpful for planning and ordering priorities for maintenance activities. The absence of such inspections often can allow alerting symptoms to go unnoticed and deterioration to worsen to such an extent that structural stability and safety are compromised. Qualified personnel, experienced in the operating behavior of structures as well as

their design, can assess adequacy of performance through the analysis of instrumentation data and the observation of behavior during service.

An example I might offer in this regard pertains to seepage which occurs through or beneath water impoundment structures. Such seepage is often considered normal and expected, with a great deal of design attention being given to its control within and beyond the boundaries of the structure. As a structure is put into service and subjected to loading variations, normal seepage develops. Knowledge of these seepage patterns, and any changes that may develop as the structure ages, are important factors to be considered in assessing the performance and safety of the structure, and can only be accomplished satisfactorily through regular, post-construction surveillance.

Instrumentation, and the rapidly advancing technology with which it is associated, is widely available in many forms to the engineering community, and has proven to be a necessary element in assessing structural safety and monitoring performance. While reliance must not be placed on instrumentation alone, if its data is competently interpreted and used in concert with a program of inspection and surveillance, it can and has provided valuable insight into internal or subsurface conditions and behavior. Data generated from instrumentation must, however, be reviewed critically by competent design personnel in a timely manner for it to be of value in assuring structural safety.

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construction practice. The best of designs, and the best of construction specifications, can be rendered ineffective and safety compromised, if construction practice is not adapted properly to actual field conditions as they become known. This is particularly true in foundation work, where the best design exploration is the construction itself, which affords an opportunity to confirm "anticipated" conditions and to adjust the design to accommodate "actual" conditions.

To further assist in averting structural failure, particularly in earth structures, recognition must also be given to the potential for latent defects which may be relevant to some structures and their site environment. These are defined as those geologic conditions which exist in nature but whose long-term engineering significance to structural performance is difficult to define. An example of such a defect is foundation cavities in solution susceptible rock formations. This phenomenon must be contended with long after construction and extended periods of successful operation. The proper resolution of such geologically adverse conditions is a thorough and sometimes costly investigation and identification of the potential for this type of problem by suitably trained and experienced professionals during the design stages of the project.

The continued safe operation and service of a structure is highly dependent upon systematic surveillance of its response to loading throughout its life, and the recognition of design loading being exceeded by changes in use of the facility. Increased truck loading on bridges is a common example.

There appears to be an increasing trend in the engineering community today to apply probabilistic theory to the engineering of structures and to assessments of their safety. Traditionally, probabilistic methods have been used

to express or quantify the recurrence likelihood of natural events, such as the frequency and duration of flooding or the occurrence of earthquakes. While these methods have proven useful for these purposes, and are considered valuable tools for making decisions in some specific types of engineering problems, their practical use and value in assessing overall risk and degree of structural safety is considered to be in a formative stage of development.

The benefits of using computers in the design and analysis of structures are immeasurable. However, incorrect use of the computer can lead to problems that cause structural failures. To prevent computer misuse or error, our policies require that all computer programs or codes be checked by manual computations and be completely documented before being distributed for use. In addition, we provide extensive training on the use of computer programs so that our engineers are knowledgeable of the technical basis of these programs and are able to interpret and verify the results.

Design, construction, and operation of safe structures is a complex problem involving an interrelationship of many people. Its success depends on the technical capability and the professional integrity of those involved.

In summary, I would say that engineers must be ever cognizant of their role in protection of the public safety and welfare and not relinquish this responsibility to economic expediency, outside influences, individual benefit, or lack of foresight and self-development.

Mr. GORE. Very good. Thank you.

Our final witness is Mr. Vincent Bush, representing the Council of American Building Officials.

Mr. Bush, welcome, and if you care to summarize some of your statement we would appreciate it.

Mr. BUSH. Yes, sir.

Thank you, Mr. Chairman and members of the subcommittee.

It gives me great pleasure today to present this statement on behalf of the Council of American Building Officials.

As you know, the Council of American Building Officials is a federation of the three model code agencies in the United States. These are Building Officials and Code Administrators International, International Conference of Building Officials, and Southern Building Code Congress International.

CABO was formed in 1971 to unify and present an umbrella organization for the hopeful unification of the building officials throughout the United States and at the same time provide a voice for the building officials in Washington and hopefully to develop uniform practices in our codes and standards so that when any builder or design engineer were working in any one area he was working in an area with which he was familiar and wouldn't find it too different in the other code areas.

The one thing that is unique among building officials is that the only vested interests that they have is public safety. There is no other interest involved and as a result the building officials look at it strictly from the standpoint of public safety.

Structural failures of building construction are almost always caused by a breakdown in our system of checks and balances. In some cases, it is an error in the original design which goes undetected until failure occurs after completion of the building. Or as we have heard, it may occur during the construction of the building.

In other cases, failures occur because subcontractors or workmen do not carry out their performance properly and important structural details are either changed or not followed and, again, these mistakes go undetected until the failure of the building.

Structural failures can be reduced significantly by proper controls generally consisting of design reviews and monitoring of construction.

First of all, there must be a review of the structural design and structural details. This is an area too often slighted by local building departments and is probably their most important function.

This function may suffer because of budget restraints, and in too many cases, it is the policy of the jurisdiction that the building department will not make reviews of the structural design and details.

In the prepared statement you probably will notice there was an attachment from the editorial of the news magazine that expressed the same philosophy, that the citizen looks to his local government for safety of his building and if he can't be assured of that safety then he feels that there is something wrong. And for this reason we feel very strongly that a design review by the local building department is a mandatory feature of their operations.

Local building departments which do not have the capability in-house for making structural reviews may avail themselves of the plan review services of the three model code groups. Each one of us has a competent and well-trained technical staff to perform this function. Another alternative is an independent peer review of the structural design and details.

We have found that when the building department review is lacking that the peer review is lacking. For whatever reason, this constant breakdown seems to take place, review of the structural design and details.

The next area for improvement is in the actual construction of the building itself. During construction we have untold opportunities for monitoring the construction to assure that the construction proceeds in accordance with the structural engineer's design and the contract documents.

One opportunity for improvement is the monitoring of construction by the design structural engineer.

We have heard an awful lot of testimony this morning about why this is not being done. The fact remains that it isn't being done. The structural engineer from the San Francisco Bay area who investigated the Kemper Arena, among other buildings, indicated to me sometime ago that in all the structural failures that he had investigated and looked at and so forth, there was one common denominator and that was the lack of monitoring of the construction by the design structural engineer.

This ran through every one of them and it is an important thing that must be changed.

Mr. GORE. How do we change it?

Mr. BUSH. This so-called litigious society that we live in is one area that really creates a lot of problems but I do know quite a few structural engineers in my own personal acquaintance, that still perform monitoring services.

And, in fact, I just couldn't help but notice, looking at a guide for structural engineering services by the Construction Engineers Association of California, that they still have in their guide for services, that during the construction phase the structural engineer shall make site visits as necessary to observe and gain familiarity with the progress of the structural work.

These construction phase services are really, I think, a euphemism for inspection because the word inspection or supervision, either one of those two words automatically carries a connotation that the structural engineer has taken over the job and this is not, of course, his responsibility but he can, and many of them do, make these inspections or construction site visits and when they see something wrong they call it to the attention of the proper authority.

The biggest problem is that it is not being done often enough. Here is an excellent text on structural and foundation failures by Barry Lapatner. I think he is going to speak to you.

Mr. GORE. He is a witness tomorrow.

Mr. BUSH. And Sidney M. Johnson is the structural engineer involved but it runs all the way through this document, design reviews and monitoring by the structural engineer that were not

taking place so it really probably is as important a part of the construction process as anything else for ferreting out these mistakes.

The construction design engineer is the only man in the whole team who knows the intent of his design. When he visits the site if he sees something wrong he is the best man and in the best position to make that determination and call it to the attention of the proper authority.

In fact, it has been said and I agree with this, that it is as much a part of his responsibility as the actual structural design calculations.

The second opportunity for improvement is in the area of inspections by the local building department. All too often building departments are impoverished and must spread their forces so thin that they cannot possibly do an adequate job.

One way to combat this situation is for building departments to charge an adequate fee structure.

This is universal in that building departments in general do not charge enough for their services and as a result they have inadequate services to operate their departments the way they should.

Also, it is important that the fees collected be retained by the building department to cover its operations and that they not be siphoned off by city management into other areas not related to the building permit activity.

Another common complaint of building departments is the fact that when they do collect fees and are a revenue-producing department that the city management then siphons that money off into other areas and this, of course, creates a problem for the building department when they don't have adequate funds from which to operate.

Another area which is a prime candidate for improvement and, insofar as inspection is concerned, probably the most important is the use of independent third party inspectors to assure quality control for the project.

Building departments cannot possibly afford to hire enough inspectors to provide continuous inspection for large and complex projects.

As a result, the framers of the Uniform Building Code as early as its first edition in 1927 included provisions in the code for independent third-party inspection by so-called special inspectors.

These inspectors are retained and paid by the owner of the project usually with the counsel of the structural design engineer.

This continuous type inspection at critical stages of the construction helps assure that the work is performed properly and in accordance with the code.

This requirement for independent third-party inspection is so important that where it is not required by the local building department, the owner should provide it.

The structural engineer should insist on third-party inspection as it is the owner's responsibility and it is also to his advantage that independent third party inspection be retained.

In summary, the incidents of structural failures of completed buildings can be drastically reduced by proper local building department operations such as structural plan review, close monitor-

ing of the construction by the department building inspectors and requiring that the owner retain independent third party inspection.

The other area of improvement is for all design structural engineers to provide construction phase services while the building is under construction. This means, of course, getting out on the job, visiting the job, making sure that it does go in accordance with our design.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Bush follows:]

STRUCTURAL FAILURES AND THE CONSTRUCTION PROCESS

Statement Prepared for the Committee on Science and Technology
of the U.S. House of Representatives

by

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for the

Council of American Building Officials

Introduction

Due to the short notice and limited time available to prepare a statement for the committee, the following has been taken in large part from a report prepared by a subcommittee of the Hazardous Buildings Committee of the California Seismic Safety Commission. This author is chairman of the subcommittee and was responsible for preparation of the report. Also included are excerpts of portions of a report prepared by the International Conference of Building Officials for the City of Kansas City, Missouri,¹ which are pertinent to the subject of building department operations as they affect the subject of this statement.

A review of the construction process requires that all participants be considered. Consideration is limited in this statement to owners, design professionals, local building departments, third party inspection agencies (for example, testing laboratories), general

¹ REPORT OF THE OPERATIONAL REVIEW OF THE CODES ADMINISTRATION DIVISION OF THE PUBLIC WORKS DEPARTMENT, KANSAS CITY, MISSOURI, CONDUCTED BY THE INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS, SUBMITTED MARCH 15, 1982.

contractors and subcontractors. Furthermore, close attention must be given to design, plan checking, quality control, inspection and performance during construction.

Safe buildings demand competence in all phases of the construction process and by all members of the building team. In the interest of preventing structural failures, we must look for actual and potential deficiencies in all aspects of the construction process. We need a firm grasp of the present state of the art in construction to guide the formulation of improvements.

The Central Problem: Breakdown in Our System of Checks and Balances

Structural failures are most always due to a breakdown in our system of checks and balances for construction projects. Structural design and detailing errors are often translated into the actual building construction because of inadequate plan review services during the building permit stage. In fact, in many cases, a review by building departments of the structural design calculations and structural drawings is not made at all. In those cases where such a review is made, problems usually arise because of budgets which are not adequate to support the hiring of competent technical help in adequate numbers. Where there is an absence of review of the structural design and drawings by local building departments, independent peer review is also typically lacking. Inspection and supervision policies instead of improving have often suffered neglect due in part to "fast-track" processes used to combat time constraints and inflation.

On-the-job construction review by qualified personnel which might prevent or correct errors in construction is typically lacking. This includes periodic on-site construction review visits by the design structural engineer and third party quality control inspections provided by the owner. Reduced building department budgets, tight private sector money, high interest rates and declining quality of professional and construction manpower are leading causes. Recent failures of relatively new buildings illustrate the severity of the problem.

Local inspection runs the gamut from very good to very poor. Budgets are typically inadequate, either due to inadequate fees or because the city administrations use excess fees over costs generated by the building department for other purposes not related to building department services. Thus, many local building departments operate with inadequate funding, staffing and employee salaries; the personnel attracted to such departments being barely adequate at best.

Major Participants in the Process: Owners, Design Professionals,
Building Departments and Contractors and Construction Personnel

Each of the major participants in the construction process has a responsibility. Let us first discuss "owners." By and large, owners are working on tight budgets and are not disposed to spend any more than they can help. So when engineers or architects recommend independent review of the design and details and independent construction review at crucial stages of the construction, owners are likely to veto these independent reviews because of cost. This is the first mistake. Owners have much to lose by not providing this independent review but justify this because presumably the building department will provide plan review and inspection of the building and anyway it will comply with the code. The result is failure to allocate adequate funding in the owner's construction budget to take care of quality control.

"Design professionals" are other important participants. If a design professional thoroughly does his job, he will make construction review visits of projects often enough to assure that the work is going according to design. He will also review fabricator's drawings of important structural components and details for the same reason. If he sees something wrong, he will call it to the attention of the proper person or authority. But most design professionals do not provide these reviews unless they get what they consider a fee large enough to cover them, particularly progress visits at the site.

In any event, many factors work against adequate construction stage services by design professionals. For example, design fees for structural engineering are usually too low. The structural engineer may have little if any of the fee left for progress visits to the job by the time he pays salaries and other operating expenses. But such visits are needed for quality control, and some jurisdictions actually require it by law. Thus, in certain cases, the structural engineer must sign a certificate when the job is completed attesting that the job complied with the drawings and design that was approved by the building department. An engineer cannot honestly sign such a certificate without making construction progress visits to make sure that the building was constructed in accordance with the design. California statutes governing public school and hospital construction require the structural engineer to sign such a statement. The design professional cannot properly do his job if he does not make progress reviews of the work. However, he should not be held responsible for the actions and performance of the other "players."

"Local building departments" are other important contributors to the building process. Many departments do poor jobs because of budget restraints. With inadequate budget allocations, they cannot hire enough competent people to properly perform plan review and inspection services. If building departments collected adequate service fees the money generated by building inspection and plan review fees could be used to retain proper numbers of competent personnel and improve performance. Such funding would also give many code enforcement agencies resources for in-house education and training, thus, increasing their level of competence.

One of the most important operational functions of a local building department (and probably one of the most neglected) is structural plan review. Inadequate structural plan review is either created by budgetary restraints, or as in many cases, it is not a policy of the local jurisdiction to make a structural plan review. Plan checking should be considered as one of the city's most important functions as it applies to the construction of structures. But plan checking cannot be casual or careless. If an important design error is not detected by a plan review, a conscientious city building inspector will insure that it becomes an integral part of the structure.

Some professional engineers are unalterably opposed to having their plans reviewed. Their objections include a conviction that they alone are responsible for the correctness of their design and an overview is pointless. Others feel a review is an attack on their abilities and integrity. Still others may resent their designs being reviewed by plans examiners who, at times, are not professionals (however, they should be). All of these objections are understandable but not valid. Self certification of a structural design correctness presupposes infallibility.

Government owes a responsibility to its citizens to provide some assurance that the structures in which they spend about 80 percent of their lives are reasonably safe. Even the most prestigious and competent designers have committed serious errors which were detected and corrected by plans examiners. Design errors which are not detected and can result in failures are always a possibility and such occurrences are not rare. As the workload of plans examiners increases, so do the possibilities of missing serious errors.

Another important function and one that is perhaps the most obvious function of a building department is inspection by department inspectors of construction during progress. Many jurisdictions place their primary emphasis upon inspections by their

department building inspectors, but even so, these inspection services are subject to the same inadequacies as other department operations due to lack of awareness on the part of public officials, budget limitations, etc. The inspection by local building inspectors is important not only to monitor the construction itself but also to monitor the inspections provided by independent third party inspectors.

Uniform Building Code provisions requiring special inspections are too often slighted in those jurisdictions adopting this code.² Virtually any job of more than just minor work is required to have the work done under special inspection. This means that independent third party inspectors expert in one or more of the construction trades and acceptable to the jurisdiction must be on the job and paid by the owner. For example, special inspection is required for all structural welding in a building by an inspector who is an expert welder. The welding inspector is required to be in continuous attendance whenever structural welding is taking place to make sure that the work is properly done. This is an excellent means of quality control, but many building departments do not properly enforce these provisions, consequently construction work may not be executed the way it should.

If every local building department religiously enforced building code requirements for "special inspection" or equivalent third party inspection requirements, our buildings would be much safer. Also, many testing laboratories maintain field staffs of qualified special inspectors so that there is a talent pool available.

The last group of major players in the process are "the contractors and construction personnel." Today's workmen are not always thoroughly conversant with their responsibilities. Only the larger contractors who do large budget jobs actually have the personnel needed for proper performance. One of the more serious problems being faced by today's contractors is the time crunch. Local, state and federal regulations are such that in many cases a job may be delayed in starting for a considerable period of time. These delays

² A copy of an article prepared by Robert E. O'Bannon, P.E., Director of Education, International Conference of Building Officials, addressing the subject of special inspection which appeared in "Building Standards" magazine, July-August, 1982, is attached to this statement. Also attached is a summary of the Uniform Building Code requirements for special inspection.

cost the contractor money in accordance with the old adage, "Time is money." Thus, in order to make up for the lost time, he must of necessity speed up the work wherever possible, usually through the means of "fast-track" procedures. Because of this necessity to speed up the work on the project, quality control and construction performance usually suffer.

Recommendations and Conclusion

Owners, developers, contractors, subcontractors and tradesmen must have the same awareness for quality control in construction that the design professionals have. These participants in the construction process also come under great pressures: the need to make profit margins, demanding work schedules, penalties for failing to meet completion dates, inflation, complex bid procedures, negative weather conditions and a host of other problems. Owners or builders may see increased costs and construction time attributable to quality control as adversely affecting the economic success of a project. Nonetheless, ways must be sought to bring these participants along.

Improvement ultimately depends on a commitment to quality, which must include adequate funding for all parts of the process. Owners must be aware of this need and must realistically appraise their total construction budgets, recognizing the need for adequate quality control throughout the process. This may call for educational efforts by the design professional (who may also need education himself). In any event, designers must do everything they can to promote quality construction and help owners understand the importance of quality and what is needed to insure it.

We must emphasize the selection of experienced design professionals and the budgeting of adequate fees that enable them to serve owners properly. We often hear that design professionals are not paid a large enough fee to perform on-site review of construction. It should be clear to all professionals that to achieve good quality, the design professional must perform construction-phase services: generally monitoring construction. Some jurisdictions require the design professional to submit written statements that buildings were constructed in general accordance with contract documents, including the plans approved by the building department. Should this become a universal practice?

There must be improvement in the funding, staffing and performance of local building departments. Moreover, building departments can materially improve matters by rigorously enforcing third party inspection requirements such as Section 306 of the Uniform Building Code. This is feasible and can bring about significant improvements in quality.

The contractor must be held fully responsible for project construction and quality in strict conformance with the contract documents. This is the contractor's basic job, regardless of how much or how little third party quality control or inspection is provided by others.

Owners must be held responsible and accountable for proper quality control of their building project during construction, as it is the owner's duty to supply a safe building upon completion. Therefore, he must retain competent design professionals, building contractors and quality control personnel. This is not to say that other participants in the construction process including the jurisdiction should not be held accountable for their actions but the owner is ultimately responsible for the final product, which is the safe building.

A breakdown in the functions of any one participant in the construction process can lead to disastrous results in the final completed building structure. After all the discussion and recommendations contained in this statement are distilled to their essence, it becomes increasingly clear that a multi-pronged attack in two areas will reap the greatest benefits in the improvement of quality control in the construction process:

1. The operations of local building departments must be oriented toward properly carrying out their responsibilities in plan checking (including checking of structural design and details) and inspection as well as rigorously enforcing the provisions of the code requiring third party inspection. Proper plan review and enforcement of third party inspection by building departments can go a long way toward improving the quality of construction. Evidently, the editors of "Engineering News-Record" place heavy importance on the operations of the local building department in the construction process as witnessed by the following editorial reprinted from its May 13, 1982, issue:

DANGEROUS IMPROVISATION

Local building departments have many different ideas about what their responsibilities are, as "Engineering News-Record" found out in talking to officials from 26 of them recently. Budgets, salaries, qualifications and procedures vary considerably. Inspections vary from constant to nearly nonexistent, and the developer's team is given varying degrees of leeway in policing itself.

Building departments have a lot going against them: public apathy, construction industry hostility, overwork and low salaries among them. But in too many cases they are not providing the service that we should expect from them.

A building department that doesn't review structural calculations, for example, is simply not doing its job. The one thing the public trusts its local department to do is to provide unbiased assurance that a structure will stand safely. And amazingly, skipping the structural review is the practice not only in backwater towns with no buildings of any great size, but in New York, where the buildings are some of the most sophisticated in the country.

Inadequacies like this don't have to be. If a department is set up correctly, all necessary functions of the department are paid for directly by permit fees. If the department can't afford to do a proper job, it should raise its fees until it can afford to, and should ensure that no fees are being drained off into other unrelated functions.

While too much can be made of accidents, fires and failures, the recent rash of them can't be ignored. It is a reminder the building-review system doesn't work as well as it should. We can't expect perfect safety, but we should be able to count on an adequate approximation.

2. It is mandatory that all of the participants in the construction process be held responsible and accountable for their performance and the owner, above all, should be held ultimately responsible and accountable for his building even though some of the other participants may be at fault where problems arise.

Although not a part of your committee's specific area of interest at the present time, it is important to stress that fire safety in buildings is another important objective of building codes. It is a parallel area of concern which poses analogous problems and submits to similar solutions as discussed previously in this statement.

In conclusion, the Council of American Building Officials stands ready to assist your committee in its investigation into the cause of structural failures by lending our expertise to you in any area involving the construction process. We are unalterably committed to improvement of the process for the benefit of public safety and welfare. CABO is unique in that our only vested interest in the construction process is public safety.

EDUCATION

The Meaning Of Special Inspection

by Robert E. O'Bannon, P.E.
Director of Education
International Conference of Building Officials

BUILDING STANDARDS, JULY-AUGUST 1983

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Section 306 of the Uniform Building Code sets forth requirements for the employment of special inspectors during certain phases of specific construction processes. These requirements are based on a need for critical attention to certain materials used, the method of application, mixing, fabrication, connection, or other applicable requirements which intend to ensure that the quality, strength or durability intended for that particular installation becomes a reality. Quite often these desired results are based on an unusually high degree of anticipated building performance in which design strengths demand the utmost of all critical components. This means that persons authorized to make the inspections must possess unique and highly developed skills in the type of construction involved.

For example, foundation concrete with strengths of 2,000 psi is reasonably simple to achieve and there is no valid reason to require special inspection in these situations. But if the design contemplates concrete of higher strength—say 2,500 to 6,000 psi—the situation becomes increasingly critical because there are factors which could interfere with the attainment of those relatively high strengths, such as excessive water, temperature, improper mix, transport or placement. The special inspector for reinforced concrete is expected to carefully observe each and every step in the processes, such as checking the placement and grade of reinforcement, as well as to make any required tests or to secure samples of materials for laboratory testing. The same is true with all other construction materials or methods of construction in which the code specifies the use of special inspectors.

As a general rule, special inspectors differ from code enforcement inspectors to the

extent that their expertise, though rather narrow in scope, is highly developed, and rightly so. They must devote a great amount of time and effort in gaining an extensive grasp and deep knowledge on the subject, or subjects, in which they desire to be experts. The code enforcement inspector should have similar qualifications, but has a much wider spectrum of involvement and cannot be expected to devote the full time required for special inspection. The code requires the building official to satisfy himself on the qualifications and competence of individuals being considered for employment as special inspectors. This is a grave responsibility and one which requires careful application. An interview with a prospective special inspector may be all that is required for certain categories, but it also means that the interviewer must himself possess skills in that particular craft or vocation. Recognition and acceptance of the credentials issued by another jurisdiction can also carry some peril unless the processes employed in the issuance of a certificate are known and acceptable to building official contemplating such recognition.

Although the code provides some authority for special inspectors to exercise enforcement for the correction of discrepancies, he should have the support of the regular inspector and the two should work as a team. When the building official approves a special inspector it is important that the ground rules are clearly understood. Such rules would include a requirement for routine written reports as well as verbal reports to the regular inspector.

As a means of assisting building officials in the administration of Section 306, ICBO, in 1980, developed and implemented a program for the examination and certification of

special inspectors. The categories now in effect are reinforced concrete; prestressed concrete (possession of a certificate for reinforced concrete is a prerequisite); structural steel welding; and structural masonry. Now under development are tests for pile driving, spray-applied fireproofing, and grading inspector.

The ICBO program will provide those jurisdictions which have no testing program of their own the means of complying with the intent of Section 306, without the necessity of developing their own examinations or relying on the certifications issued by other communities. It will also provide qualified inspectors with credentials that have no geographical limitations and will assure employment in any area which will recognize ICBO certification.

The program also has renewal provisions on the same three-year cycle as code enforcement certifications. This provision is to ensure that those who are certified by ICBO keep themselves current with codes and the state of the art. Also, under development is a system for disciplinary action and a procedure for appeals.

There is no intent to make any overt, or covert, attempt to abrogate any existing programs—nor to denigrate their quality. The sole intent is to provide an additional service to the membership and for individuals who are affected.

In summary, it must be stated that the use of qualified special inspectors, although not a panacea, can materially assist in achieving the level of structural integrity intended by designers and materials manufacturers. In these days of more complex construction systems, the need for increased inspection is certainly justified. ■

SUMMARY OF UNIFORM BUILDING CODE PROVISIONS FOR SPECIAL INSPECTION

The first publication of the Uniform Building Code in 1927, contained provisions for special inspection. It was realized that it was not possible for the building department to provide and maintain sufficient personnel to fully inspect all facets of complex construction as required by the code. Accordingly, the concept of "special inspection" was incorporated into the requirements of the Building Code.

The 1979 edition of the Uniform Building Code requires that special inspection be provided in accordance with Section 306 of the code as follows:

1. CONCRETE: During the taking of test specimens and placing of all reinforced concrete and pneumatically placed concrete.

EXCEPTIONS: 1. Concrete for foundations conforming to the minimum requirements of Table No. 29-A of this code and for Group R, Division 3 and Group M, Division 1 Occupancies, provided the building official finds no special hazards exist.

2. For foundation concrete when the structural design is based on a f'_c no greater than 2000 psi.

3. Nonstructural slabs on grade, including prestressed slabs on grade when effective prestress in concrete is less than 150 pounds per square inch.

4. Site work concrete full-supported on earth and concrete where no special hazard exists.

2. DUCTILE MOMENT-RESISTING CONCRETE FRAME: As required by Section 2626 (h) of this code.

3. REINFORCING STEEL AND PRESTRESSING STEEL: A. During all stressing and grouting of prestressed concrete.

B. During placing of reinforcing steel, placing of tendons and prestressing steel for all concrete required to have special inspection by Item No. 1.

EXCEPTION: The special inspector need not be present during entire reinforcing steel and prestressing steel-placing operations, provided he has inspected for conformance with the approved plans prior to the closing of forms or the delivery of concrete to the job site.

4. WELDING: A. Ductile moment-resisting steel frames. As required by Section 2722 (f) of this code.

B. All structural welding, including welding of reinforcing steel.

EXCEPTIONS: 1. When welding is done in an approved fabricator's shop.

2. When approved by the building official, single-pass fillet welds when stressed to less than 50 percent of allowable stresses and floor and roof deck welding and welded studs when used for structural diaphragm or composite systems may have periodic inspections as defined in Section 306 (e) of this code. For periodic inspection, the inspector shall check qualifications of welders at start of work and then make final inspection of all welds for compliance prior to completion of welding.

5. HIGH-STRENGTH BOLTING: During all bolt installations and tightening operations.

EXCEPTIONS: 1. The special inspector need not be present during the entire installation and tightening operation, provided he has:

(i) Inspected the surfaces and bolt type for conformance to plans and specifications prior to start of bolting, and

(ii) Will, upon completion of all bolting, verify the minimum specified bolt tension for 10 percent of the bolts for each "type" of connection, for a representative number of total connections established by the plans and specifications.

2. In bearing-type connections when threads are not required by design to be excluded from the shear plane, inspection prior to or during installation will not be required.

6. STRUCTURAL MASONRY: During preparation of masonry wall prisms, sampling and placing of all masonry units, placement of reinforcement, inspection of grout space, immediately prior to closing of cleanouts and during all grouting operations. Where the f'_m is less than 2600 psi and special inspection stresses are used, test specimens may consist of either one prism test for each 5000 square feet of wall area or a series of tests based on both grout and mortar for the first three consecutive days and each third day thereafter.

EXCEPTION: Special inspection will not be required for structures designed in accordance with the values in appropriate tables for noncontinuous inspection.

7. REINFORCED GYPSUM CONCRETE: When cast-in-place Class "B" gypsum concrete is being mixed and placed.

8. INSULATING CONCRETE FILL: During the application of insulating concrete fill when used as part of a structural system.

EXCEPTION: The special inspections may be limited to an initial inspection to check the deck surface and placement of reinforcing. The special inspector shall supervise the preparation of compression test specimens during this initial inspection.

9. SPRAYED-ON FIREPROOFING: As required by U.B.C. Standard No. 43-8.

10. PILING, DRILLED PIERS AND CAISSONS: During driving and testing of piles and construction of cast-in-place drilled piles or caissons. See Items Nos. 1 and 3 for concrete and reinforcing steel inspections.

11. SPECIAL GRADING, EXCAVATION AND FILLING: During earth-work excavations, grading and filling operations inspection to satisfy the requirements of Chapter 29 and Chapter 70 (Appendix) of this code.

12. SPECIAL CASES: Work which, in the opinion of the building official, involves unusual hazards.

As Items Nos. 1 through 12 are reviewed, it becomes readily apparent that the types of construction described are of such a nature that constant supervision or inspection would be required to ascertain that the construction complies with the requirements of Uniform Building Code and the design specifications. For example, if the job specification requires concrete to have an ultimate compressive strength of 4000 pounds per square inch, at 28 days, it is imperative that inspection procedures be established to ascertain that the concrete in the structure does meet this strength requirement at the specified date. To insure that the concrete is in accordance with specifications, it is necessary that a full time inspector be on the job site to determine that representative concrete strength tests are made, proper placing techniques are used, etc.

As part of the duties and responsibilities of the special inspectors the code requires the following:

1. The special inspector shall observe the work assigned to be certain it conforms to the design drawings and specifications.
2. The special inspector shall furnish inspection reports to the building official, the engineer or architect of record, and other designated persons. All discrepancies shall be brought to the immediate attention of the contractor for correction, then, if uncorrected, to the proper design authority and to the building official.
3. The special inspector shall submit a final signed report stating whether the work requiring special inspection was to the best of his knowledge in conformance with the approved plans and specifications and the applicable workmanship provisions of these codes.

The 1979 edition of the Uniform Building Code further allows the building official to waive the requirements for employment of a special inspector if he finds the construction is of a minor nature. The code also permits periodic special inspection, provided it can be determined that the work can be so evaluated to provide reasonable assurance that it meets code requirements.

Mr. GORE. Thank you very much.

At the bottom of page 6 in your prepared text you say that, "Some jurisdictions require the design professional to submit written statements that buildings were constructed in general accordance with contract documents including the plans approved by the building department."

Then you pose the question, "Should this become a universal practice?"

Let me pose that question to you. Should it?

Mr. BUSH. I think it should become a universal practice in large and complex structures.

Mr. GORE. Well, in those jurisdictions that do require the design professional to certify in writing that the work has been conducted in accordance with the design, do you find that that requirement works to get the design professional out on the jobsite looking carefully at the work in progress?

Mr. BUSH. Yes, sir, it does, very much.

Mr. GORE. What percentage of jurisdictions have this kind of code requirement?

Mr. BUSH. I don't know the actual percentage, Mr. Chairman, but I would say it is almost negligible. I only know of a few in California, the Office of the State Architect in California requires it for school building and hospital construction.

Mr. GORE. Well, I would say to my colleague that one of our recommendations in the report as a result of this set of hearings might be that the code officials and this umbrella organization recommend the universal adoption of that kind of code requirement for major structures.

Let me ask you, Mr. Bush, does your organization make recommendations for the universal model code? What is it called?

Mr. BUSH. The Council of American Building Officials.

Mr. GORE. No; the Uniform Building Code?

Mr. BUSH. Oh, yes.

In the case of the organizations I am employed by it is the Uniform Building Code. The building code administrators have a basic code and there is the standard building code. Each one of those could well carry such a recommendation.

Mr. GORE. What is the process, who writes the Uniform Building Code?

Mr. BUSH. It is written by our building official members. They meet in committees and consider propositions for changing or bringing the code up to date.

Mr. GORE. And if a recommendation of this kind was made, how long would it take, assuming it met with general approval, how long before the Uniform Building Code could be changed to reflect that?

Mr. BUSH. Assuming, as you say, that it would meet with the approval of all concerned it would take about 2 years.

Mr. GORE. And then, how long after that would it show up in building codes around the country?

Mr. BUSH. It would vary. It would be another year to 2 years or even 3 years in some cases.

Mr. GORE. In some cases, I take it, local codes reference the Uniform Building Code?

Mr. BUSH. This is in most areas. Either one of the three model codes are referenced by local jurisdictions.

Mr. GORE. What are the other two model codes?

Mr. BUSH. The basic building code of the Building Code Administrators International up in Chicago.

Mr. GORE. Is that a competing group to yours?

Mr. BUSH. Yes, sir.

The third one is the Southern Building Code Conference International and they publish the Standard Building Code.

Mr. GORE. So if we really wanted to cover the bases we would make such a recommendation to all three organizations.

Mr. BUSH. Well, I think the best place would be our umbrella organization, CABO.

Mr. GORE. Of course, we would start with you and then get in touch with the others just to make sure.

Mr. KUCHNICKE. I just wanted to clarify what CABO is all about. The board of directors of CABO consists of the three model code organizations. So if the recommendation came to CABO then you would have agreement of all three organizations if the recommendation came to us.

We also have a board for the coordination of model codes which their purpose is to work toward uniformity between the three.

So that recommendations go to that board and they would develop language that would be compatible for all three documents.

Mr. GORE. Well, you know everybody that has testified here has identified this as the major problem contributing to the incidence of major structural failures around the country.

So it seems to me your organization certainly has a clearly identified course of action here if you are going to fulfill the responsibility to the public which inheres in your association.

Mr. GORE. Mr. Winn?

Mr. WINN. Thank you, Mr. Chairman.

The Uniform Building Code is pretty well known in the industry.

The Southern—what is that again? I know there is a differentiation and I want to know what they call it.

Mr. BUSH. The organization is the Southern Building Code Congress International and their code is called the "Standard Building Code."

Mr. WINN. Why is that separate? That is a competing organization?

Mr. BUSH. They are a competing organization.

Mr. WINN. Does the fact that it is southern have anything to do with it, the fact that there would be different requirements for building in the South?

Mr. BUSH. Not very much, Mr. Winn. In fact, their requirements are very similar to ours in the Uniform Building Code.

Mr. WINN. And you all put our publications with your various codes in them?

Mr. BUSH. Yes, sir; that is correct.

Mr. WINN. So, practically every city then, and I suppose county, too, would have access to one of the three main building code organizations.

Mr. BUSH. That is correct; yes sir.

Mr. WINN. Let's just say pick a city at random, say Denver, would Denver's building codes be the same as the Uniform Building Code or the Standard Building Code or one of the three?

Mr. BUSH. Well, in the particular case of Denver they write their own code but it is very similar to the Uniform Building Code.

Let's take Kansas City, a city you are very familiar with, they adopt by reference the Uniform Building Code as the city code.

Mr. WINN. Well, let's get into this. I may be wrong but every time I see a city that would go off on their own with their own building code, even though it may be similar to the Uniform Building Code, it isn't necessarily the Uniform Building Code as is. It may be better. It may be a little more lax.

Is that true?

Mr. BUSH. I am sure that could be true.

Mr. WINN. It could be. I don't know what they have in their code.

Mr. BUSH. Right.

Mr. WINN. What is the reason for that? What is the reason for them not adopting one of the three standard codes but having their own?

Mr. BUSH. Well, in the opinion of the local professionals and I include not only the local city governments but the design professionals, architects and engineers within that local community. Apparently they feel that they have either unique problems or that they are better able to prepare a set of regulations for that jurisdiction.

Mr. WINN. Well, that could be, they have an unusual soil problem out there that I am aware of.

Mr. BUSH. That could well be.

Mr. WINN. I suppose you would have to obviously consider the fact that they are building on the side of the mountains, too, which might have something to do with it.

How much differences are there between the codes? Is there a big difference between the three main codes or is it relatively small?

Mr. BUSH. Well, it is not relatively small but is sort of in between. I guess I would say, The Standard Building Code in the South is very similar and very close to the Uniform Building Code and its requirements, the way it is organized and so on.

The basic code of the Building Officials and Code Administrators International is quite a bit different than the other two.

Mr. WINN. It seems like you all agree. If you all agree that having a design professional on the scene is a good idea, then why isn't that spelled out in the codes or is it?

Mr. BUSH. It is not spelled out in the code?

Mr. WINN. Why is it not?

Mr. BUSH. Well, these things require proposal by someone, either the design professions or building officials or someone of that type and this proposal has not been made.

Mr. WINN. Should it be in there?

Mr. BUSH. I think so; yes, sir.

Mr. GORE. Would you agree with that, Mr. Duscha?

Mr. DUSCHA. I think it should be. I think it should be a requirement of any type of design and construction program.

Mr. WINN. Is there an outside pressure that keeps it out of there for any reason?

Mr. BUSH. I don't know, Mr. Winn. I haven't been able to put my finger on it. Sometimes everybody thinks that everything is going along all right as it is and as a result the changes are not proposed.

Mr. GORE. Would my colleague yield?

Mr. WINN. Certainly.

Mr. GORE. Isn't it fair to assume that there is an economic pressure here because a requirement that the design professional continue to be present during construction would tend to add some increment of cost to the structure?

Mr. BUSH. I am sure it would; yes, sir.

Mr. GORE. But as the experience is highlighted during these hearings illustrate, that is a penny-wise and pound-foolish saving because it shows up all too frequently in the form of failures later on and this results in extra insurance costs for everybody and extra litigation, and so forth.

Mr. BUSH. Yes, sir; that is true.

Mr. WINN. The last question, Mr. Chairman.

I wonder if you all would care to comment on any apparent trend in attitude or deeper concern on quality control in the construction industry?

AGC and some of the rest of them must be having additional panels and forums and things on some of these collapsed buildings, particularly the one in Fairfax right outside town here a few years ago, and then the one down in Cocoa Beach.

Mr. BUSH. In general, the design professionals with whom I have spoken and many of us feel that quality control and construction in general is not the same as it used to be. In other words, it has suffered over the years.

One part of that problem as indicated in the prepared statement, is that general contractors are fighting the regulations scheme, if you want to call it that, where virtually everybody has a regulation that involves his work, local building codes, local city planning agencies, State requirements for whatever reason in the case of many of them, State energy requirements or coastal commissions. So as a result, the general contractor may spend 6 or 8 months or even longer before he even gets his job into the permit stage. And then from there he may spend another 2 or 3 weeks or 1 month before he actually gets out on the job and gets it started.

Mr. WINN. I don't believe you mentioned that some States have what they call certified builders, certified contractors. I believe California is one.

Mr. BUSH. That is right. So as a result he has been faced with so many delays in getting his job started that many of them go to this so-called fast track type of construction whereby they start construction even before the contract documents are completely prepared and they will start after the architect and engineer have given them a foundation plan and the rest of the job is still in the planning stage.

This just creates all kinds of problems.

Mr. WINN. I know of several examples of that where the contractor was gone. He puts the foundation in and he doesn't have the first floor plan. He gets to the first floor and barely gets that in

time and he doesn't have the second or third floor and they are building as the design comes in, as the architects bring it in.

Mr. BUSH. That is correct. This is a real problem in maintaining quality control.

Mr. WINN. It must be. It has to be.

Mr. BUSH. To monitor the construction when you don't even know what the upper floors of the building look like and whether you have the proper loads designed for it, it really makes it a tough proposition.

Mr. WINN. Mr. Duscha?

Mr. DUSCHA. I would like to second what Mr. Bush has said. We in our organization have also noticed a decrease in quality control with our contractors over time and we really don't know what is causing this or what is the basic issue behind it.

We have become so concerned that we are starting a special study to find out what is causing this problem, and what we should do to overcome the problem.

Mr. WINN. What can we in the Congress do to help you strengthen their backs?

Mr. DUSCHA. Well, I think you have offered us an opportunity for this group making the special study. It will certainly want to see what has been accomplished here and what has been surfaced related to their area to help them along.

Mr. WINN. So you would welcome something along the lines that Mr. Gore is talking about as far as something in the Bureau of Standards?

Mr. DUSCHA. Absolutely. I think I would second anything that gives us the full range of information that is necessary to solve the problem.

Mr. WINN. The trouble is you could put all the information in the world in a clearinghouse and if there isn't some ramrod there to kick them in the duff a little bit or something to make them measure up, then you get into sloppy construction and lack of quality control.

Mr. DUSCHA. That is absolutely right and what is needed, as was said by the earlier panel, is the local officials or State officials to enforce the laws and protect the welfare of its citizens, basically.

Mr. WINN. And how do you get away from payoffs?

Mr. DUSCHA. I don't know, sir.

Mr. WINN. That was my last question.

Mr. GORE. We don't want to get into the Judiciary Committee's turf.

Let me thank you all.

Would you be willing to answer additional written questions for the record?

Mr. BUSH. Yes, sir.

Mr. DUSCHA. We certainly would.

Mr. GORE. It seems to me if we had a clearinghouse of information and requirements that there be a fixed point of responsibility, and continued supervision and continued presence by the design professional during the construction process we would be a long ways down the road toward solving the problems that led to so many of the structural failures that led to this hearing.

I might note for the record and just ask you to agree briefly, Mr. Bush, if you do, that codes don't relieve the responsibility of the architect or engineer for going beyond the codes if that is necessary in their judgment. That is basic, isn't it?

Mr. BUSH. Truer words were never spoken, Mr. Chairman.

Mr. GORE. Have you experienced in the corps, Mr. Duscha, because of your organizational makeup, have you found that you are better able to keep tabs on quality control because of the fixed responsibility?

Mr. DUSCHA. Yes, I think so. Because both entities come under one head at some point in time, both the engineering and the construction.

Mr. GORE. Well, tomorrow morning at 9:30 in this room we will continue with the second day of these hearings and I would like to again thank you as members of our last panel today and we will stand in recess until tomorrow morning at 9:30.

[Whereupon, at 1 p.m., the subcommittee was recessed, to reconvene at 9:30 a.m., Wednesday, August 4, 1982.]

STRUCTURAL FAILURES

WEDNESDAY, AUGUST 4, 1982

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:40 a.m., in room 2325, Rayburn House Office Building, Hon. Albert Gore, Jr. (chairman of the subcommittee) presiding.

Mr. GORE. The subcommittee will come to order.

[The opening prepared statement of Mr. Gore follows:]

OPENING STATEMENT OF HON. ALBERT GORE, JR.

Today marks the second day of our inquiry into major structural failures.

Last year, as a result of such major failures as the collapse of both the pedestrian walkway at the Hyatt Regency in Kansas City and the roof of the Hartford Civic Center in Connecticut prompted the Subcommittee to conduct a inquiry into major structural failures in the United States. The purpose of our inquiry has not been to find blame for a particular incident, but rather to determine whether or not there are generic causes for these failures; either in the design research or the technology of the building industry.

Based on our work to date, the Subcommittee has come to some preliminary conclusions: there seems to be a lack of communication between the major participants in the construction team, there is a disturbing absence of institutionalized Quality Control, the role of the design engineer in ensuring the quality of construction has been unwisely limited, and there are hazards accompanying the trend toward designing major structures by computers, without the benefit of judgment and experience of the engineers. All of these influences appear to have a negative impact on the quality of our major structures. The Subcommittee intends to expand its data base by sending out a questionnaire to a much larger sample of the building industry, including architects, engineers, contractors, developers, and bankers. It is our belief that such data, along with the information gathered at these hearings will serve as a useful basis for the Subcommittee to make recommendations to the relevant professions, and to explore our legislative options.

Yesterday, our proceedings made it exceedingly clear that there is an undesirable lack of communication between the various components of a "team" put together to build a major structure. Secondly, we established that this lack of interface was largely attributable to liability considerations; in our litigious society, and concern for liability are supplanting overall concern for quality. Third, the lack of communications leads to a disturbing phenomenon where no one, especially the structural engineer, is responsible for ensuring the overall quality of the structure. Lastly, we observed a disturbing phenomenon wherein the technical causation of many failures are kept under legal wraps. The settlement of the problem with falling windows from the Hancock building in Boston, for instance, precluded disclosure of the cause of that disaster. It appears that we are not even afforded the opportunity to learn from our mistakes. Today, we look forward to exploring these issues; since we have a lawyer before us, we can explore these issues of liability, and with our second panel we might learn how perspectives can vary, depending on what end of the construction business you happen to be involved with.

I would like to welcome our witnesses and our guests. Today is the second day of our inquiry into the causes of major structural failures in the United States.

Last year, as a result of such major failures as the collapse of both the pedestrian walkway at the Hyatt Regency in Kansas City and the roof of the Hartford Civic Center in Connecticut, the subcommittee conducted an inquiry into major structural failures in the United States. The purpose of the inquiry has not been to find blame for a particular incident but rather to determine whether or not there are generic causes for these failures, either in the organization of the building industry or in design, construction, or technology employed. Based on our work to date, the subcommittee has come to some preliminary conclusions.

First, there seems to be a lack of communication between the major participants in the construction team organized around specific projects.

Second, there is a disturbing absence of institutionalized quality control.

Third, the role of the design engineer, the design professional, in insuring the quality of construction according to the design has been unwisely limited. Fourth, there are apparently hazards accompanying a trend toward designing major structures by computer without the benefit of additional judgment and experience inherent in engineers. All of these influences appear to have had a negative impact on the quality of our major structures. The subcommittee intends to expand its data base by sending out a questionnaire to a much larger sample of the building industry including architects, engineers, contractors, developers, and bankers. It is our belief that such data, along with the information gathered at these hearings, can serve as a useful basis for the subcommittee to make recommendations to the relevant professions and to explore our own legislative options.

Yesterday, our proceedings made it exceedingly clear that there is an undesirable lack of communication between various components of a team put together to build major structure.

We established that this lack of communication was, in large part, attributable to liability considerations. In our litigious society, concern for liability are apparently supplanting overall concerns for quality. This lack of communication leads to a disturbing phenomena where no one, especially not the structural engineer, appears to be responsible for insuring the overall quality of the structure under construction.

We observed the disturbing phenomena where the technical causation of many failures are sometimes kept under legal wraps. The settlement of the problem with the falling windows out of the John Hancock Building in Boston, for example, precluded disclosure to the professions of the cause of that disaster. It appears that in some instances we are not even afforded the opportunity to learn from major mistakes.

Today we look forward to exploring these issues further, so we have a lawyer before us. We can explore the issues of liability, and with our second panel, we might learn how perspectives can vary depending on what end of the construction business you happen to be involved with.

I look forward to today's witnesses.

I would like to ask unanimous consent that the opening statement of our ranking minority member on the full committee, Mr. Winn of Kansas, be put into the record at this point and the statement of the ranking minority member of the subcommittee, Mr. Walker of Pennsylvania, be put into the record at this point. They have both been very helpful in this investigation and have a particular interest in it.

We have two panels and I am pleased to welcome the members of our first panel.

[The prepared statements of Messrs. Winn and Walker follow:]

OPENING STATEMENT OF THE
HONORABLE LARRY WINN, JR. (R-KAN.)
SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT
HEARING ON STRUCTURAL FAILURES
August 4, 1982

THANK YOU, MR. CHAIRMAN, FOR THIS OPPORTUNITY TO
WELCOME OUR WITNESSES THIS MORNING.

YESTERDAY, WE HEARD FROM A NUMBER OF PROFESSIONAL
PARTICIPANTS, REPRESENTING SEVERAL FACETS OF THE CON-
STRUCTION INDUSTRY, FROM ARCHITECTURE TO STANDARDS. THE
INFORMATION WE RECEIVED WAS VERY HELPFUL AND ITS DIVERSITY
WAS INDICATIVE OF THE MANY VIEWPOINTS AND CONSIDERATIONS
IN THE CONSTRUCTION INDUSTRY.

THERE ARE THOSE WHO BELIEVE THAT THE FEDERAL GOVERNMENT
SHOULD REMAIN OUTSIDE THE CONSTRUCTION INDUSTRY, THAT WE
SHOULD HAVE FEW, IF ANY, FEDERAL REGULATIONS IMPOSED ON
THAT ACTIVITY. FROM MY OWN EXPERIENCE OF MANY YEARS IN
THE INDUSTRY, I CERTAINLY DO NOT ADVOCATE ADDITIONAL LAWS
AND REGULATIONS THAT COULD IMPEDE THE FREE ENTERPRISE
SYSTEM OR CONSTRUCTION PROCESSES. HOWEVER, IT DOES APPEAR
TO ME THAT THE INDUSTRY COULD USE SOME MOTIVATION TO IMPROVE
AND INCREASE THE AMOUNT OF CRITICAL INSPECTION DURING THE

CONSTRUCTION PHASE. THAT INSIGHT IS VERY HELPFUL, AND WE ANTICIPATE ADDITIONAL GUIDANCE FROM OUR WITNESSES TODAY.

WE ARE GLAD YOU CAN BE WITH US TODAY, AND WE LOOK FORWARD TO HEARING FROM YOU.

AGAIN, MR. CHAIRMAN, THANK YOU.

OPENING REMARKS OF CONGRESSMAN ROBERT S. WALKER

AUGUST 4, 1982

MR. CHAIRMAN, YESTERDAY, WHILE WE SAT IN THIS ROOM DISCUSSING THE PROBLEMS OF STRUCTURAL FAILURES AND THE RISKS THAT THEY NOW PRESENT TO THE AMERICAN PUBLIC, ANOTHER FAILURE OCCURRED IN NEAR-BY VIRGINIA, NOT TEN MILES FROM WHERE WE SIT. ACCORDING TO THE MORNING NEWSPAPER IT WAS NOT A BIG ACCIDENT. THERE WERE A FEW INJURIES, SOME TENS OF THOUSANDS OF DOLLARS OF PROPERTY DAMAGE. AND I HAVE NO DOUBT THAT, EXCEPT FOR THOSE ACTUALLY INVOLVED, THIS PARTICULAR ACCIDENT WILL BE SOON FORGOTTEN.

BUT, BASED ON THE TESTIMONY THAT WE HEARD YESTERDAY, EVEN AS THAT ACCIDENT WAS OCCURRING, IT IS SAFE TO MAKE TWO STATEMENTS ABOUT THAT ACCIDENT. THE FIRST IS THAT THERE WAS PROBABLY NO ARCHITECT OR STRUCTURAL ENGINEER ON THE SCENE OF THE ACCIDENT. AND THE SECOND IS THAT IF ONE OF THOSE DESIGN PROFESSIONALS HAD BEEN THERE THE ACCIDENT PROBABLY COULD HAVE BEEN AVOIDED.

YESTERDAY WE HEARD FROM WITNESS AFTER WITNESS THAT THERE IS A COMMON DENOMINATOR IN STRUCTURAL FAILURES -- AND THAT IS THE ABSENCE OF THE DESIGN PROFESSIONALS FROM THE CONSTRUCTION SITE. AND WE WERE TOLD THAT IF THOSE DESIGN PROFESSIONALS HAD BEEN PRESENT AND ACTIVELY SUPERVISING THE CONSTRUCTION OF THE BUILDING THAT THEY DESIGNED TO FULFILL THE DEVELOPER'S DREAM, THEN MOST STRUCTURAL FAILURES COULD PROBABLY BE AVOIDED.

OUR TESTIMONY YESTERDAY DESCRIBED A SCENE IN WHICH OUR LEGAL SYSTEM IS ACTING TO KEEP THE DESIGN PROFESSIONALS AWAY FROM ACTUAL CONSTRUCTION FOR THE SIMPLE REASON OF AVOIDING LIABILITY FOR ACCIDENTS. THERE IS NO QUESTION THAT IF THE DESIGN IS FAULTY, AND CAUSES A STRUCTURAL FAILURE, THEN THE DESIGN PROFESSIONAL IS UNDOUBTEDLY LIABLE FOR THE DAMAGES.

BUT WHAT WE WERE TOLD YESTERDAY WAS THAT IF THE DESIGN IS ADEQUATE, BUT THE GENERAL CONTRACTOR, OR ONE OF HIS SUB-CONTRACTORS, IS NOT FOLLOWING THE DESIGN EXACTLY, AND THIS IS DISCOVERED BY THE DESIGN PROFESSIONAL, HE MAY BECOME LIABLE IF HE TAKES ANY DIRECT SUPERVISORY AUTHORITY OVER THE PROJECT.

I AM NOT A LAWYER. BUT COUNSEL ADVISES ME THAT THE REASON FOR THIS IS THAT IN MOST STATES THERE IS WHAT THE LAWYERS CALL "PRIVITY" FROM THE DEVELOPER THROUGH THE GENERAL CONTRACTOR AND HIS SUB-CONTRACTORS TO THE WORKERS ON THE JOB. IN VIRTUALLY ALL CASES, IF A WORKER IS INJURED, HE IS LIMITED TO WORKMAN'S COMPENSATION BECAUSE OF THIS PRIVITY. BUT, IF THE DESIGN PROFESSIONAL HAS BEEN ACTIVELY INVOLVED IN THE SUPERVISION OF THE PROJECT, AND KNEW, OR SHOULD HAVE KNOWN, OF THE HAZARD WHICH EXISTED, THEN HE CAN BE FOUND LIABLE.

AS A RESULT OF THIS SITUATION, WE WERE TOLD THAT THE LAWYERS ADVISING ARCHITECTS AND STRUCTURAL ENGINEERS, AS

WELL AS THEIR INSURANCE REPRESENTATIVES, WARN THEM TO LIMIT THEIR LIABILITIES BY NOT BECOMING DIRECTLY INVOLVED.

THIS IS NOT THE CORRECT FORUM FOR ADDRESSING THE ADEQUACY OR INADEQUACY OF WORKMAN'S COMPENSATION REMEDIES. AND I DO NOT BELIEVE THAT WE CAN POSSIBLY LEGISLATE STRUCTURALLY SAFE BUILDINGS. BUT I CANNOT HELP BUT NOTE THAT THERE IS SOMETHING FUNDAMENTALLY WRONG WITH THE WAY THE SYSTEM IS WORKING HERE.

THE PRIMARY PURPOSE FOR GOVERNMENTAL POLICIES SHOULD BE TO PROTECT THE PUBLIC WELFARE. IT SEEMS OBVIOUS TO ME THAT, PARTICULARLY IN THE CASE OF BUILDINGS WHICH ARE CONSTRUCTED FOR PUBLIC USE, THE PUBLIC IS BEST PROTECTED BY MAKING SURE THAT THE BUILDING IS PROPERLY CONSTRUCTED. AND WHO CAN POSSIBLY BE BETTER QUALIFIED TO OVERSEE THAT CONSTRUCTION THAN THE MAN WHO CONCEIVED THE STRUCTURE IN THE FIRST PLACE? THE DESIGN PROFESSIONAL HAS HAD EXTENSIVE TRAINING AND EDUCATION IN THE INTERRELATED DISCIPLINES OF ARCHITECTURE AND ENGINEERING. HE UNDERSTANDS EXACTLY WHAT THE INTENDED LOADS ARE, AND HOW THEY ARE TO BE SPREAD THROUGHOUT THE STRUCTURE.

THERE SEEMS LITTLE QUESTION THAT IF OUR GOAL IS TO PROTECT THE PUBLIC, THEN THE DESIGN ENGINEER CAN, AND SHOULD BE ALLOWED FREE ACCESS TO THE CONSTRUCTION SITE, AND THE ABILITY TO ACTIVELY PARTICIPATE IN THE SUPERVISION OF THE PROJECT WITHOUT PENALTY. IN FACT, WE SHOULD ENCOURAGE THAT PARTICIPATION.

PERHAPS TODAY WE WILL BE ABLE TO DISCUSS THIS WITH OUR
WITNESSES AND DETERMINE IF THERE ARE ACTUALLY WAYS TO ACCOMPLISH
THIS GOAL WITHIN THE CURRENT LEGAL SYSTEM.

THANK YOU.

Mr. GORE. The panel members are Mr. C. Roy Vince, vice president of the Shand, Morahan Co. in Evanston, Ill., who is accompanied by Bert M. Thompson, counsel to Shand, Morahan, and Mr. Barry LePatner, attorney and coauthor of the "Structural and Foundation Failures," a case book for architects, engineers, and lawyers.

Welcome, gentlemen. Without objection, your entire prepared statements will be included in the record in full at this point.

I invite you to summarize those portions of your statement as you think are appropriate to summarize.

Mr. Vince, we will begin with you. Thank you for coming.

STATEMENTS OF C. ROY VINCE, VICE PRESIDENT, SHAND, MORAHAN & CO., INC., EVANSTON, ILL., ACCOMPANIED BY BERT M. THOMPSON, COUNSEL; BARRY B. LePATNER, ATTORNEY AND COAUTHOR OF STRUCTURAL FAILURES TEXT, NEW YORK, N. Y.; AND EDWARD PFRANG, CHIEF, STRUCTURES DIVISION, NATIONAL BUREAU OF STANDARDS, WASHINGTON, D.C.

Mr. VINCE. I am glad to be here and I am glad Mr. Thompson, counsel for Shand, Morahan could accompany me.

As you stated, I am vice president with Shand, Morahan & Co. and my duties are governed primarily in dealing with matters involving claims in the construction industry.

Shand, Morahan & Co. is the underwriting manager for various insurance companies and its principal business is providing coverage for professional lines, architects and engineers included. Shand, Morahan also writes other risks that find limited markets in the standard insurance markets. We write, architects and engineers professional liability and we stepped into a void in this area 12 years ago and began our business in that field at that time.

Today, the business that we have for architects and engineers is shared with another major underwriter. There are two other underwriters that are involved in what we believe to be a smaller market share and there are several other underwriters that write some of this business.

Within the last year, Shand, Morahan has expanded its involvement in the construction industry by introducing two new products which are project performance coverage, which insures that a project will meet the criteria that was originally contemplated, and we introduced another coverage which is constructors. This provides coverage for faulty workmanship on the project which we feel fills in certain gaps that are now in existence in the standard market.

As a result of our involvement in this business we have over 10,000 construction claim investigations that we have conducted and on these investigations we maintain statistical records. We maintain these records to determine eligibility, pricing to design loss avoidance tools and to improve the experience of the companies that we represent.

Our statistical studies indicate a primary conclusion that I would like to state first, and then get into some of the backup information, that structural failures are predictable. That frequency and severity within limits can be anticipated.

I will be using the term frequency and severity quite often.

I would just like to define that term frequency as the number of times that you will see a particular occurrence. Severity is the amount of loss measured in dollars, not in human life or any other measure but measured in dollars. By way of illustration of this point I would like to discuss briefly some of our risks that have a combined frequency and severity below the norm; risks that we insure such as electrical engineers, heating and air conditioning engineers, land surveyors and civil engineers all of which have an incidence of loss below the norm.

Both architects and engineers fall near the norm. Structural engineers who are primarily involved in the structural systems of the building have a frequency of approximately 5 percent lower than the norm and a severity rate of approximately 15 percent higher than the norm.

The professions who would be affected by structural failure, in conclusion, are experiencing a higher severity rate but only slightly higher.

Recently we have been able to improve our data capture systems to provide some additional detail that bears on the subject that this committee is studying. We recently sampled 12 percent of our claims of recent vintage in conjunction with this more sophisticated data capture system and we have concluded that design construction and complete service firms have a severity in excess of 250 percent of the norm.

In examining this result we have determined that this is due primarily to the involvement of these firms and major projects and the fact that these firms incorporate within their structure a greater number of disciplines and consequently are exposed to a greater number of things that may go wrong in connection with a construction project.

Of all claims relating to the structural professional disciplines and we are including here structural engineers and those disciplines that are embodied in the firms that I just spoke of, we find that severity is 1.5 times the average of the sample.

The severity is about 1 in 30 of these claims. When we categorize these claims in terms of those professions that are involved in the structure of buildings, we find that less than half of these claims are classified as what we would term structural failures. And the severity for these claims is about $2\frac{1}{2}$ times that of the norm. Of these claims, about half involved the structural systems of the building and we find that the severity rate associated with these claims is approximately three times the norm.

I would like at this point to interject a caution when considering these figures and that is, unlike figures that might be generated from the automobile business or homeowners business, our sample is small. There is limited actuarial credibility to such data when you are dealing with a relatively small sample.

However, in spite of this, we believe that the sample I have just discussed is representative of the 10,000 construction investigations that we have in our files and we believe that it is reflective of the experience that the balance of the market has had in dealing with similar construction problems.

As you pointed out a little bit earlier, a number of national failures, failures of national significance, have drawn attention to the construction industry. The Hartford Civic Center, the Teton Dam, Kemper Arena, Kansas City Hyatt, the Post Center, the Hood Canal Bridge, the Lyndon Baines Johnson Library, have all concerned us and concerned us greatly.

We certainly believe, as you do, that society can benefit if such failures are avoided. However, our experience in this area concludes that structural failures did not occur as a result of common denominators or groups of common denominators. The exceptions to this general statement are those structural failures that are associated with what we will term acts of God, such as earthquake, hurricane, or tornado. Our studies indicate that several events which act uniquely in combination produce the disasters that we have studied. We feel that the study of structural failures can improve our technical knowledge of structural performance but aren't likely to anticipate those unique combination of events which produce the structural failures—examples of which I have just cited.

The insurance industry has, through its history, utilized the principles-of-loss engineering to avoid adverse experience. This has been applied to commercial lines, to workers' compensation, to make plants safer for workers, and cut down the incidence of loss.

This has been applied to property coverages. It has been applied to boiler and machinery insurance specifying relief valves on pressure vessels as an example of the kind of involvement the insurance industry takes in loss avoidance.

Shand, Morahan & Co. has studied ways to apply its knowledge to loss engineering in the construction field. We have learned that there are some tools that are available toward this end such as pre-claim counseling, applying sound management techniques, constructing defensive tools, following sound contracting methods, and instituting quality control methods. Based on these studies and the application of these methods by ourselves and others, we conclude that these can assist in claim resolution in conflict situations but have no real proven value in preventing building failure.

We have concluded that claims in the construction industry are the result of either building malfunction, financial hardship, or a combination of both.

To construct more technically oriented loss-engineering tools, Shand, Morahan has studied its failure inventory to find the elements where both high frequency and high severity exist. We conducted a study of building-system failures and this study revealed that 41 percent of the building failures that have occurred in our sampling have dealt with roof- and wall-system failures.

The study also reveals that the frequency between wall failures and the frequency between roof failures is about equal.

Our sample showed something that was a little bit surprising to us, however, and that was that of wall failures. We determined that the payments in the reserves in connection with wall failures are approximately 150 percent of all claims.

And we have determined that wall failures, as compared to roof failures, have twice the severity. Roof claims appeared by studying these cases individually to have no common denominator except

failures that appear associated with acts of God, heavy snowstorms, unusual wind or rain conditions, that kind of thing.

Wall-system failures, however, revealed that there were persistent problems with product performance, construction techniques, and design techniques.

As a result of this study, Shand, Morahan, in connection with a Chicago chapter of the AIA, the University of Illinois, and recently the University of Maryland, has undertaken a program to deal with these perceived problems.

By 1984, we expect to complete the program and the program will be made available to the design community and the construction community. The information will be in the form of symposium, seminars, published articles, transcripts, and video tapes. We intend to produce a comprehensive publication which will be addressing technical methods to avoid wall failure problems.

To summarize both this brief discussion and the information that is contained in the report that I have provided to the committee that is part of the record, I would like to make the following statements:

First, we have found that serious structural failures are relatively few in number. Structural failures occur randomly but are statistically predictable. The overall effect of serious structural failures on the loss ratio of both standard and specialty insurers does not impact to a point that these impair the industry's ability to continue to afford current protections.

Second, there appears to be an existing effort of the standard market to broaden individual risk coverages.

Third, the specialty market has expanded, both in terms of numbers of insurers and also capacity, so that there is greater interest in insuring the design of structures. The specialty market is expanding to significantly broaden the protection it is willing to offer for both performance and for workmanship on a construction project.

Fourth, the loss experience of the insurers of architects and engineers is more adversely affected by financially oriented claims than structural failures. Delay claims, cost overruns, and plant performance problems have greater financial impact.

Fifth, the construction community is involved in serious and effective efforts to minimize structural failure. The construction insurance industry, both the standard industry and specialty industry, is addressing prevention through loss engineering.

In conclusion, I would like to say that our observations suggest that structural failures occur from a combination of events which are unique to the project rather than a single cause that may be repetitive in future projects.

We commend the interest of the committee in this important subject and we thank you for the opportunity to express our views.

[The prepared statement of Mr. Vince follows:]

STATEMENT OF SHAND, MORAHAN & COMPANY, INC.
TO THE COMMITTEE ON SCIENCE AND TECHNOLOGY
CONCERNING ITS INVESTIGATION OF
STRUCTURAL FAILURES

Good morning. My name is C. Roy Vince. I am a Vice President with Shand, Morahan & Company, Inc., one of the largest underwriters of Architects and Engineers Professional Liability Insurance. In this capacity, Shand, Morahan functions as an underwriting manager for various insurance companies. We are generally referred to as a specialty market.

We also provide coverage in other lines of professional liability such as lawyers, physicians, accountants, directors and officers, insurance company, and hospitals. In addition we insure a myriad of other risk categories which find a limited market for adequate coverage. However, it is our experience in Architects and Engineers professional liability, project performance coverage, constructors errors and omissions coverage, which bears on the work of your Committee.

As Vice President at Shand, Morahan and one of its subsidiaries, Evanston Insurance Company, both firms located

at Evanston, Illinois, my activities are primarily directed toward dealing with construction industry insurance claim problems.

As I understand it, the purpose of this hearing is to review the underlying causes behind structural failures which have occurred in public facilities over the past six years, with a view to find the way to plan, design, finance, manage and construct such facilities.

Shand, Morahan, 12 years ago, filled a void in the insurance market by providing coverage for Architects and Engineers at a time when there was one principal domestic market and a limited foreign market. Today, Shand, Morahan shares the bulk of the market with one other underwriter. The balance of the market is shared by two other underwriters with a long term presence and several others who write some coverage in this class of business. Other construction oriented coverages include Project Performance coverage and Constructors Errors and Omissions coverage. The former covers costs associated with meeting production expectations. The latter includes coverage for faulty workmanship.

Responding directly to the purpose of your hearings,

Shand, Morahan has in its files in excess of 10,000 investigations which deal with professional liability claims against architects and engineers. It is from this experience, that the following is offered for consideration by your Committee.

The insurance industry maintains comprehensive statistical records. These records serve several purposes, to provide information for underwriters as to eligibility and pricing, development of loss avoidance tools, and to improve the experience of the company through the process of risk selection. These statistics are at the foundation of the insurance business.

Architects and Engineers professional liability statistics have been maintained by Shand, Morahan in certain broad categories, since inception. This includes information as to classification of risk, specialty of insured, size, type of project, construction values, annual billings, geographical areas, loss of risk, loss location, and causes of loss.

The insurance industry, as have other businesses, improved its information gathering techniques with greater use of computer technology. Since 1981 these refinements have better enabled us to track the causative factors of

loss. For the purpose of your Committee, I would like to state the portion of the thesis of our report that pertains to the result of our statistical studies and comment on some general information which touches on structural failures.

Our experience and studies indicate that structural failures are predictable. The frequency and severity emanating from such failures within specific limits can be anticipated, over a given number of years, in accordance with the principles of statistical probability.

Before addressing ourself specifically to structural failures some information on losses should be imparted. Our statistics on architects and engineer losses indicate that complete service firms and design/build firms have a frequency of loss 250 percent or higher, and a severity rate over 50 percent higher than single discipline firms. This is understood when one considers that these firms are involved in major projects, and do a greater amount of construction as well as exercise a broader responsibility over the work.

Certain classes of risks, such as electrical engineers, heating and air conditioning engineers, land surveyors, civil engineers have combined frequency and severity rates more than 40 percent below the norm of all these insured

classes. As to claim frequency, architectural firms and structural engineering firms both fall near the norm. Architects, however, have a relatively small incidence of catastrophic loss. The incidence of such losses for structural engineers is somewhat higher. In terms of comparison, structural engineers have a frequency rate about 5 percent lower than all insured design professionals and a severity rate about 15 percent higher than this insurance classification. These overall studies indicate that those disciplines, whose experience would normally be skewed by serious structural failures, are, in fact, experiencing higher severity rates but not to the point that these cannot be dealt with in the ordinary course of the insurance process. Design Construct, Complete Service Firms, and Structural Engineers fall into this category.

With the added capability of improved data capture, we were able to identify a group of 1218 reported claims in 1981 and examine them with a view toward isolating structural failures. With respect to the severity figures associated with these claims, it has to be considered that many of these cases are open and unresolved. Consequently, these figures may be subject to change as developments take place, causing reevaluation prior to actual resolution of the case. Eighty-eight of the 1218 sampled claims had a loss cause

relating to the structural professional discipline. The severity of those claims equalled approximately 1.5 times the severity of the sample. Of the claims involving this discipline, 38 were classified as structural failures. The severity of these claims were 2.5 times the norms. Of the 38 claims involving structural failure, 20 affected the structural systems of the projects. The severity of these claims was slightly in excess of 3 times the norm. In viewing these figures, we should note that these figures take into account only covered losses and relate to the policy limits exposed for each loss. Further, unlike coverages such as automobile and homeowners in which large numbers of individual risks are used, the numbers of design professionals are so small that there is limited actuarial credibility to any given data.

Also, for Architects and Engineers as for most professions, enough claims are reported to give credibility for all the risks combined, but it is difficult to support differentials based upon classifications within a given profession. The subjective judgment of the underwriter is a major factor when interpreting professional lines.

In spite of these cautions we believe this sample is in accord with our general experience and representative of our

10,000 claims. In addition we expect these results are reflected closely in the balance of the market underwritten by others.

The sample of 1218 claims utilized has a greater significance in terms of severity than the absolute number of claims would indicate. This is true because the program had a coverage limit of 25 million dollars. This is significant because the losses experienced by the carrier would track closely with actual severity because design professionals tend to buy policy limits in accordance with their perceptions as to the possibility of catastrophic loss. Those involved in larger projects will tend to buy higher limits. The insurers in this business understand the insureds perceiving minor potential losses will purchase low limits and those perceiving catastrophic potential will purchase higher limits. The law of large numbers allows insurers to spread these certain losses over a large number of risks. In the specialty market where the statistical base is small, greater reliance is placed on underwriting judgment to interpret actuarial studies.

This analysis should also consider, from the insurance industry point of view, the position of contractors, subcontractors, manufacturers and suppliers. We cannot, with

any authority, speak for carriers engaged in providing coverage to those risks in the standard market. However, from our experience in handling construction industry claims, we are acquainted with the way structural failures affect insurers of these other participants. We have seen experience paralleling our own.

Our conclusion is that structural failure is not imposing undue pressures on these insurers to meet the needs of their construction industry clients. Further supporting this view are indications that both standard and speciality markets are expanding their products to broaden protections available to construction industry insureds.

Finally, an additional factor demonstrates that structural failures are not so imposing a problem as to prevent them from being contemplated within existing rate structures. Both through underwriting latitude and through broadening of the policies, the industry is assuming the financial burden of structural failure.

A number of failures occurred which have focused national attention on the construction industry; Hartford Civic Center, Teton Dam, Kemper Arena, Kansas City Hyatt Regency Hotel, C.W. Post Center of Long Island University,

Hood Canal Bridge, Lyndon Baines Johnson Library. These are certainly of concern. Of less national significance are the partial failures that occur (in accordance with the previous study) at a rate of about one in every 30 claims. The majority of these failures are corrected with minor cost and inconvenience. The vast majority of serious claims on structures relate to financial loss due to increased costs, dissatisfaction with waterproofing, utilities, electrical, mechanical and other such problems, rather than structural failure.

Regardless of the degree of concern one attaches to structural failures, if methods can be applied to prevent such failures, society will benefit. Since the Committee is concerned about ways to plan, design, finance, manage and construct structures to avoid failures, a perspective from a construction industry insurer may be of value on that subject.

The science and art of building construction is an evolving process. Designers and builders are utilizing new concepts and materials. The needs of owners and developers are placing more technical demands upon constructors. Codes and standards are being updated. Regulatory bodies are attempting to deal with technological advances. As a

natural reaction, all these parties direct attention to ways to reduce the frequency and severity of structural failures through the collection and feedback of information on such failures. Thought has been given to relating a design concept to similar concepts to learn from the performance of structures already constructed. It has been suggested that an innovative design should be subjected to a panel of recognized experts to critique the approach. A national center has been suggested to investigate failures.

These sort of suggestions are premised upon an assumption that a common denominator exists that, when discovered and applied, can prevent similar disasters. We have not found this to be the case. Instead we have found that each structural failure (with few exceptions, such as acts of God) occurs as the result of not one but several events when acting in combination, produce the disaster. Thus, any study will broaden our base of technical knowledge but is not likely to prevent future structural failure.

Within the insurance industry the principles of loss control and loss engineering are regarded as essential elements in maintaining a positive competitive posture. Mitigation of loss improves the viability of insurance. Society is spared the events associated with adverse experience.

The standard market has long applied these principles to commercial lines, workers compensation, property, boiler and machinery coverages and others.

Loss control and loss engineering generally fall into two categories, active and passive. Passive controls impose minimum standards for a particular risk in order to qualify it for available coverage, such as the presence of handrails on staircases or the existence of relief valves of provable quality on pressure vessels. Active controls include building and plant inspections, investigations into the cause of accidents, the development of plans to avoid occurrences. Construction insurers, governmental bodies as OSHA, local building departments, supervising architects and engineers act on the construction site to enforce design criteria and construction requirements. All these provide loss engineering services.

Some architects and engineers believe that many of the problems of professional liability are rooted within their own methods of practice. At least three insurers which provide professional liability insurance have worked closely with their professional clientele to develop helpful programs. The research and information obtained lead most of the market to focus attention primarily on improving management

skills in the design and construction processes and better understanding of legal problems such as trends in the law and the implementation of defensive tools. Much of this work of a preventative nature has centered on such activities as encouraging teamwork in the construction process, resolving problems and conflicts at an early stage, pre-claim counseling, allocating responsibilities clearly by contract and devising better checks on the quality of the work.

Shand, Morahan has studied the problems of building failures with respect to the way in which it might improve the loss experience of its insureds and came to some conclusions which might be of value to your Committee in studying structural failures. Our study confirmed that structural failures are the result of unique sets of circumstances. There appear to be no causative common denominators that tie groups of these losses closely together. We also found little to support the contention that claims are avoided when sound management techniques, quality control systems, or sound contracting techniques are applied. Such claims, however, do lend themselves to more favorable disposition when the parties to the process that have been meticulous in the execution of their obligations. We also concluded that claims in the construction industry are the result of either building malfunction or financial hardship

befalling one or more of the parties to the construction process.

Shand, Morahan has, as have other professional liability carriers, offered information to the design community on contracting and proven management practices. A non-standard feature of its architects and engineers policies provide for reporting of facts and circumstances which give rise to a claim in order to avoid the future claim. This has enabled us to address problems in the formative stage with the view of minimizing loss.

By contrast, Shand, Morahan undertook a study of its failure investigation inventory with a view toward determining whether a common denominator existed in the area of failure where the elements of high frequency and high severity both occurred.

A study of building system failure, including site work, foundation systems, structural systems, wall systems and roof systems revealed that 41 percent deal specifically with roof and wall system failures. Although the total number of claims involving wall systems is essentially the same as those involving roof systems, 11.2 percent walls and 11.7 percent roofs, there is a dramatic difference in severity.

Claims involving wall failures are the most severe with combined payments and reserves of 1.5 times the average severity for all claims. The average severity for roof claims is less than 50 percent of that for wall claims.

An analysis of the specific claims revealed that in the category of roofing failure there appeared to be no common denominator except for the frequency of failures precipitated by "Acts of God", excessive snow falls and other severe storm conditions.

In addition, in the area of wall system failures, there appeared to exist problems with product performance, construction techniques and design techniques. Based upon this study, we concluded a need existed for more advanced technology to address wall system problems.

In conjunction with the Chicago Chapter of the AIA and the University of Illinois we conducted a further review. Recently, we obtained assistance from the University of Maryland. We intend the program to be complete by late 1983 or early 1984. Informative papers, transcripts, video tapes, articles, symposiums, seminars, have been and will be made public. The planned culmination of this effort will be a comprehensive publication addressing technical methods to avoid wall failure problems.

In Summary:

- We have found that serious structural failures are few in number.
- Structural failures occur randomly but are statistically predictable.
- The overall effect of serious structural failures on the loss ratio of both standard and speciality insurers does not impact to a point that these impair the industry's ability to continue to afford current protections.
- There appears to be an existing effort by the standard market to broaden, for individual risks, the traditional construction coverages.
- The specialty market has expanded both in terms of numbers of insurers and also capacity so that there is greater interest in insuring the exposure from the design of structures.
- The specialty market is expanding to significantly broaden the protection it is willing to offer for performance as well as workmanship.
- The loss experience of insurers of architects and engineers is more adversely affected by financially oriented claims than structural failures. Delay claims, cost overruns, plant performance problems are of greater financial impact.

- The construction community is involved in serious and effective efforts to minimize structural failure.
- The construction insurance industry, both standard and specialty is addressing prevention through loss engineering.

Our observations suggest that structural failures occur from a combination of events which are unique to the project rather than a single cause that may be repetitive in future projects.

We commend the interest of the Committee in this important subject. We wish to thank you for this opportunity to express our views.

MR. GORE. Well, thank you.

I will look forward to exploring your views and questions, particularly your statement that you don't believe there are common denominator causes. Other parts of your statement seem to point to things which I would argue fit that description and perhaps there is a problem of definition.

I take it that Mr. LePatner has a somewhat different view but, again, maybe that is a matter of definition.

Let me invite you to proceed with your statement, Mr. LePatner. Welcome.

MR. LEPATNER. Thank you very much, Mr. Chairman, members of the committee.

My name is Barry LePatner. I am an attorney with offices in New York City with a practice devoted almost exclusively to the representation of architectural and engineering firms.

I am also a professional affiliate of the New York City chapter of the American Institute of Architects.

In recent years, major failures have captured headlines across this country. And, though very few of these catastrophes have resulted in a loss of lives, the impact on the public has, nevertheless, been dramatic.

Newspaper and magazine articles, reporting on these failures, have focused their attention on the issue of design adequacy. Only the most cursory lip service has been given to the myriad other factors that play a part in every such failure.

The public has even begun to question the expertise, judgment, and professional ethics of the design profession. And, to the consternation of many of us who serve these professions, there has been no effort to respond to those assertions despite the fact that many of them are completely unfounded.

Yet, the fact remains that, with few exceptions, the average person knows little about modern-day design and construction.

The public's perception of the architectural and engineering professions is such that a poll of the electorate would be unlikely to turn up a significant number of people who could identify even the foremost names in these fields.

Yet, the role and function of today's architects and engineers has captured the apparent fascination of the public, as evidenced by Tom Wolfe's book on modern architecture which has reached best-seller lists across the country.

Despite this allure, the public's image of architects and engineers remains two dimensional. Without a true understanding of the training, skills, and qualities needed to orchestrate a successful project, even those who retain an architect often fail to appreciate the diverse responsibilities and pressures that come to bear in bringing a project to fruition.

It is this lack of knowledge as to how buildings are designed and constructed that must be overcome before this committee can fulfill its mandate.

Although each project that has resulted in a structural failure has its own life force, its own unique history, there is one general conclusion that can be made: Each of these failures could have been avoided.

As a lawyer who has been actively involved in the representation of architects and engineers for nearly a decade, I have had the opportunity to appreciate the complexities of structural designs ranging from hotels to bridges, from parking facilities to major office towers, from stadiums to sewage treatment plants.

During this time I have represented architects, engineers, and their professional liability insurers in thousands of claims, several hundred of which involved structural failures of one kind or another.

As counsel to numerous A/E firms and as a professional affiliate of the New York City chapter of the AIA, I write and speak frequently on ways to avoid professional liability claims.

From this perspective, I would offer several observations to the committee.

First, where structural failure has resulted from design error or omission, the problem is often attributable to seemingly minor details rather than a major defect in structural design.

An axiom of the design profession states that "details make or break the job." Certainly, to those of us who follow failures closely, the chain of events which led to the Kansas City Hyatt Hotel collapse reinforces this important message of how details can be overlooked within the context of a major project.

Second, ever-increasing costs of construction, including high interest rates for construction loans, have brought pressure to bear upon owners to accelerate the time necessary for the design and construction of a project. In turn, this has placed greater pressures on the design team to short circuit some traditional steps in order to meet the owner's accelerated schedule.

Third, changes to the design during construction can create a ripple effect on work already completed or in progress. Owners who decide to increase the scope of a project once the design has been completed and approved rarely comprehend the extent of modifications to the design that such changes entail.

Similarly, contractors who seek a substitution for materials specified in the plans, or who suggest alternative methods of construction as a means of saving time and cost, rarely concern themselves with the additional effort required by the architect and engineer to determine if the proposed substitution will have an impact upon the structural integrity of the building as originally designed.

Fourth, the use of innovative design and recently developed materials appears not to have been the cause of a significant number of failures.

The overwhelming majority of projects built today must, by virtue of cost considerations, be of standard design and construction techniques. The introduction of new design concepts and their attendant construction complexities is a luxury that few builders can afford. As a result, where advanced design has been utilized, it is most frequently underwritten with greater attention to detail, coupled with increased inspection by the engineers during the construction phase.

Fifth, there is a critical need for greater on site presence by structural engineers during construction-phase activities. Building owners must be willing to commit greater resources to this critical

phase of the work in order to insure that a proper structural design is not affected by changes made in the field.

Several prominent structural engineering firms today refuse to accept commissions unless they are also retained to place full-time resident engineers at the site during critical periods of construction. Every owner should view such a final check on the design as a minimal investment of fees which will return a maximum of protection against potential problems.

Sixth, little, if any, information pertaining to recent structural failures has been made public. As a result, engineers employing designs similar to those that have failed are unable to be certain that their own projects will not fall prey to an oversight or error that could have been avoided if such knowledge were widely disseminated.

It has been said that "Good judgment is usually the result of experience. And experience is frequently the result of bad judgment." But to learn from the experience of others requires those who have had the experience to share the knowledge with those who follow.

The recently settled litigation involving Boston's John Hancock Building highlights this point. During 7 years of litigation, millions of dollars were spent by the various parties in securing legal and expert analysis of the window failures and related structural problems. The notoriety of this case led to the expectation that such exhaustive investigation by the Nation's foremost engineering experts would lead to improved design at best, and, at the least, methods by which future failures of this kind could be avoided. To the amazement and chagrin of many, when this case was settled, the parties secured a court order sealing all records of this action. One can only hope that when the litigation involving the Kansas City Hyatt collapse is concluded, the various expert reports, however conflicting, will be made public so that the lessons of that failure can be utilized to avoid a tragic recurrence.

In seeking to ascertain the underlying causes of structural failures, it is essential that this committee recognize that it is dealing with a limited set of circumstances. Though this may be a legitimate area of public inquiry and concern, it is not one which can be regulated by legislative enactment. While there may be room for improving building codes or their enforcement, there can be no effective way to legislate good judgment, proper training or practical experience. Nor should there be any reason to question the dedication or professionalism of the thousands of architects and engineers who are responsible for the design each year of billions of dollars of new construction.

Yet, there is ample room for creating a heightened sensitivity toward potential problems and avoidance of future catastrophes. Toward this end, I would offer the committee several suggestions that could increase professional awareness in these areas of concern.

In order to heighten awareness of potential problems that can be avoided, I would call for organizations such as the the American Institute of Architects and the National Society of Professional Engineers to establish seminars and clinics where their members could learn from the mistakes of others—a program totally impos-

sible today because of the dearth of verifiable source material from actual cases.

I would call upon trade and professional journals to report in greater detail the technical information pertinent to significant failures. These publications will more capably serve their professional readerships by providing an open exchange of ideas, aiding both designers, and the public at large.

I would call upon the Nation's schools of architecture and engineering to introduce courses which analyze design and construction claims in much the same way that graduate schools of business study corporate failures and successes. For it is through the mistakes of others that fledgling architects and engineers can gain the insight and foresight necessary to avoid their own errors in the years ahead.

There will be no simple formula to preventing building failures in the years ahead. History shows us that man is full of imperfections and these tragic occurrences are unlikely to be eliminated totally.

It will only be through the dedicated efforts of all parties to the construction process that future failures will be minimized and many more detected before they occur.

Thank you.

[The prepared statement of Mr. LePatner follows:]

TESTIMONY OF BARRY B. LePATNER, Esq.

In recent years, major structural failures have captured headlines across this country. And, though very few of these catastrophes have resulted in a loss of lives, the impact on the public has, nevertheless, been dramatic.

Newspaper and magazine articles reporting on these failures have focused their attention on the issue of design adequacy. Only the most cursory lip service has been given to the myriad other factors that play a part in every such failure. The public has even begun to question the expertise, judgment and professional ethics of the design profession. And, to the consternation of many of us who serve these professions, there has been no effort to respond to those assertions despite the fact that many of them are completely unfounded.

Yet the fact remains that, with few exceptions, the average person knows little about modern-day design and construction. The public's perception of the architectural and engineering professions is such that a poll of the electorate would be unlikely to turn up a significant number of people who could identify even the foremost names in these fields.

There is an interesting dichotomy to all of this. While most of the public readily expresses a lively interest in the role of architecture in our society, the layman barely comprehends the way in which creative architectural and engineering ideas are transposed from the drawing board to reality. Television, that pervasive purveyor of mass-information, has taken us into the

courtroom and hospital to observe the realities (and sometime unrealities) confronting the legal and medical professions. Recent movies have shown us how journalists can go beyond reporting the headlines to making them. No such similar treatment of architects or engineers has been popularized.

Yet, the role and function of today's architects and engineers has captured the apparent fascination of the public as evidenced by Tom Wolfe's book on modern architecture which has reached best-seller lists across the country. Despite this allure, the public's image of architects and engineers remains two-dimensional. Without a true understanding of the training, skills and qualities needed to orchestrate a successful project even those who retain an architect often fail to appreciate the diverse responsibilities and pressures that come to bear in bringing a project to fruition.

It is this lack of knowledge as to how buildings are designed and constructed that must be overcome before this Committee can fulfill its mandate. For though each project that has resulted in a structural failure has its own life force, its own unique history, there is one general conclusion that can be made: Each of these failures could have been avoided.

As a lawyer who has been actively involved in the representation of architects and engineers for nearly a decade, I have had the opportunity to appreciate the complexities of structural designs ranging from hotels to bridges, from parking

facilities to major office towers, from stadiums to sewage treatment plants. During this time I have represented architects, engineers, and their professional liability insurers in thousands of claims, several hundred of which involved structural failures of one kind or another. As counsel to numerous A/E firms and as a professional affiliate of the New York City Chapter of the AIA, I write and speak frequently on ways to avoid professional liability claims.

From this perspective, I would offer several observations to the Committee.

1. Where structural failure has resulted from design error or omission, the problem is often attributable to seemingly minor details rather than a major defect in structural design. An axiom of the design profession states that "details make or break the job." Certainly, to those of us who follow failures closely, the chain of events which led to the Kansas City Hyatt Hotel collapse reinforces this important message of how details can be overlooked within the context of a major project.

2. Ever-increasing costs of construction, including high interest rates for construction loans, have brought pressure to bear upon owners to accelerate the time necessary for the design and construction of a project. In turn, this has placed greater pressures on the design team to short-circuit some traditional steps in order to meet the owner's accelerated schedule.

3. Changes to the design during construction can create

a ripple effect on work already completed or in progress. Owners who decide to increase the scope of a project once the design has been completed and approved rarely comprehend the extent of modifications to the design that such changes entail. Similarly, contractors who seek a substitution for materials specified in the plans, or who suggest alternative methods of construction as a means of saving time and cost, rarely concern themselves with the additional effort required by the architect and engineer to determine if the proposed substitution will have an impact upon the structural integrity of the building as originally designed.

4. The use of innovative design and recently developed materials appear not to have been the cause of a significant number of failures. The overwhelming majority of projects built today must, by virtue of cost considerations, be of standard design and construction techniques. The introduction of new design concepts and their attendant construction complexities is a luxury that few builders can afford. As a result, where advanced design has been utilized, it is most frequently underwritten with greater attention to detail coupled with increased inspection by the engineers during the construction phase.

5. There is a critical need for greater on-site presence by structural engineers during construction phase activities. Building owners must be willing to commit greater resources to this critical phase of the work in order to ensure that a proper structural design is not affected by changes made in the field.

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Several prominent structural engineering firms today refuse to accept commissions unless they are also retained to place full-time resident engineers at the site during critical periods of construction. Every owner should view such a final check on the design as a minimal investment of fees which will return a maximum of protection against potential problems.

6. Little, if any, information pertaining to recent structural failures has been made public. As a result, engineers employing similar designs are unable to be certain that their own projects will not fall prey to an oversight or error that could have been avoided if such knowledge were widely disseminated. It has been said that "Good judgment is usually the result of experience. And experience is frequently the result of bad judgment." But to learn from the experience of others requires those who have had the experience to share the knowledge with those who follow.

The recently settled litigation involving Boston's John Hancock Building highlights this point. During seven years of litigation, millions of dollars were spent by the various parties in securing legal and expert analysis of the window failures and related problems. The notoriety of this case led to the expectation that such exhaustive investigation by the nation's foremost engineering experts would lead to improved design at best, and methods by which future failures of this kind could be avoided, at worst. To the amazement and chagrin

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of many, when this case was settled, the parties secured a court order sealing all record of this action. One can only hope that when the litigation involving the Kansas City Hyatt collapse is concluded, the various expert reports, however conflicting, will be made public so that the lessons of that failure can be utilized to avoid a tragic recurrence.

In seeking to ascertain the underlying causes of structural failures, it is essential that this Committee recognize that it is dealing with a limited set of circumstances. Though this may be a legitimate area of public inquiry and concern, it is not one which can be regulated by legislative enactment. While there may be room for improving building codes or their enforcement, there can be no effective way to legislate good judgment, proper training or practical experience. Nor should there be any reason to question the dedication or professionalism of the thousands of architects and engineers who are responsible for the design each year of billions of dollars of new construction.

Yet, there is ample room for creating a heightened sensitivity towards potential problems and avoidance of future catastrophes. Towards this end, I would offer several suggestions that could increase professional awareness in these areas of concern.

In order to heighten awareness of potential problems that can be avoided, I would call for organizations such as The American Institute of Architects and The National Society of Professional Engineers to establish seminars and clinics

where their members could learn from the mistakes of others -- a program totally impossible today because of the dearth of verifiable source material from actual cases.

I would call upon trade and professional journals to report in greater detail the technical information pertinent to significant failures. These publications will more capably serve their professional readerships by providing an open exchange of ideas, aiding both designers, and the public at large.

I would call upon the nation's schools of architecture and engineering to introduce courses which analyze design and construction claims in much the same way that graduate schools of business study corporate failures and successes. For it is through the mistakes of others that fledgling architects and engineers can gain the insight and foresight necessary to avoid their own errors in the years ahead.

There will be no simple formula to preventing building failures in the years ahead. History shows us that man is full of imperfections and these tragic occurrences are unlikely to be eliminated totally. It will only be through the dedicated efforts of all parties to the construction process that future failures will be minimized and many more detected before they occur.

Mr. GORE. Thank you very much. I really enjoyed that testimony.

Mr. Vince, when you insure a construction team and an architect and an engineer, you insure all three, don't you?

Mr. VINCE. We insure primarily architects and engineers and we also insure construction managers and we insure design builders.

Mr. GORE. Do you have the opportunity to insist on certain minimum conditions for covering a client?

Mr. VINCE. We have information on the risk that is submitted to us by a broker on application forms which includes information concerning the past business of the applicant, the future intentions of the applicant, the nature of the projects that the applicant has been involved in, information on losses experienced and other such data.

Mr. GORE. Well, it is common for insurance companies to tell a potential client, we strongly advise you to do this or that in order to minimize the chance of loss. Otherwise, it will cost you more, or otherwise you will have to look elsewhere. You engage in such conversations with your clients, don't you?

Mr. VINCE. We, as an insurer of design professionals have no inherent technical knowledge that we feel we can apply to the business of architects and engineers.

Mr. GORE. I am not talking about technical knowledge. I am talking about things like a requirement that there be continuing attention onsite by the structural engineer while construction is in process.

Have you ever suggested to a client that that is a good idea?

Mr. VINCE. We don't get involved that intimately in our projects. We have become aware, for example, that an architect or engineer as a normal part of its services will provide onsite services. If the insured does not provide an onsite service we will take that into consideration when we underwrite the risk with a view toward the belief that if an engineer is onsite that the chances of a claim being presented against that engineer are less than if the engineer has no onsite responsibility.

But we don't make a requirement——

Mr. GORE. Wait a second. Let me ask you to say that again.

If the engineer is onsite during construction——

Mr. VINCE. We would believe from an underwriting point of view that that engineer would be available to interpret his plans and specifications and provide additional information to the contractor apart from the construction documents and we would take that into consideration in the underwriting process in favor of the insured when we would rate the risk.

Mr. GORE. Well, we had testimony yesterday that was counter to that.

First of all, an architect said that he was advised that, for legal considerations, if the contract doesn't provide specifically for the architect to stick around and supervise the work, that the lawyers tell them to stay off the construction site.

We had testimony from a consulting engineer who said that his insurance company or his insurers often advise him and consulting engineers generally to wear blinders when they walk on the construction site in order to avoid liability.

Mr. VINCE. I personally would not pass that kind of information on to an insured, nor do I think it is the practice of our company or the companies that we represent to give that sort of advice.

Mr. GORE. Well, I take your word for what you say about your company but the witnesses yesterday representing architects and engineers talked like that was just common knowledge in the industry that the insurers and lawyers told them to keep out of the process as much as possible to minimize liability.

Mr. VINCE. Might I speculate?

Mr. GORE. Sure.

Mr. VINCE. Not having been a witness to the testimony, I would think that perhaps what they were saying is that they may have been advised by their lawyers not to volunteer and assume responsibility which they had no obligation to assume.

That certainly may be some advice that they received. We certainly wouldn't encourage any engineer or architect on a construction site who saw a defect that could endanger either property or people to refrain from taking whatever steps necessary to see that the condition is corrected.

Mr. GORE. Well, again the testimony yesterday was that even when a consulting engineer found a defect, they were advised to suggest that there might be something worthy of increased attention but not to say outright that this has to be changed because it is a major hazard.

Mr. VINCE. I have encountered that attitude over a number of years.

Mr. GORE. On the part of whom?

Mr. VINCE. On the part of architects and engineers. Wherever we have encountered that attitude we have discouraged it as a method of dealing with that kind of a problem.

Mr. GORE. Good.

This problem arises, according to our witnesses yesterday, only in those circumstances where the organization of the construction team denies them a continuing responsibility for insuring that the construction goes according to the design.

And the organizational pattern that has developed as a result of this pressure to shorten the construction timetable that you refer to, Mr. LePatner, has apparently, according to our witnesses yesterday, led to patterns of organizations, ad hoc organizations built around a particular project, that minimize the role of the design professional and structural engineer. And in those circumstances which, evidently are increasingly common, the architect and the engineer venture onto the site at their legal peril and interpose their judgments at some peril of increasing their liability.

Mr. LePatner, you are an expert in this area. What is your reaction? I know you are a lawyer in this area and have that point of view but how do you feel about the effect of pervasive litigation on the construction enterprise?

Mr. LePATNER. Well, I think the coordination question here and the interplay between the design team, the owner, and the construction team is one that is critical to this committee's inquiry. Because, in many ways, each of those interests are intended to interface in a smooth way and in reality, in many ways, they have an adversarial relationship.

The designer wants to design with every possible inclusion for safety, with every possible inclusion for esthetics and would like the time to do all of those things as he has been well versed from his days in architectural-engineering schools.

The owner can't afford that time consideration even in the best of financial times. The contractor bids because he expects to complete a project within a certain amount of time and every day after that costs him money out of his own pocket.

So that once you understand that ongoing relationship, which is constantly in a state of flux during the construction process, is taking place you can realize the very numerous types of situations which can upset the balance of having a smooth flowing project. On most projects there are always ups and downs and as I have told many groups of architects and engineers, if you study any project, no matter whether it is the most smoothly flowing one or one that is rife with problems, each one of those projects has its own story to it because of the interplay of each of these interests.

But I think what this committee must understand is that there are great pressures that come to bear on an architect and engineer to insure that his design, for which he has gotten the owner's approval, gets carried through to completion.

When you have problems during a project, whether they are delays, cost overruns, whether they are questions that come up in the field as to doing something differently than what is shown on the plans, the pressure from the owner is, well, let's do it cheaper.

The contractor can't get certain materials. He says let's substitute this other material. I can't get what I had agreed to provide. It is not available. I can do it cheaper. The architect and the engineer must make the decisions. They are the final judges of the design criteria and it is imperative from their standpoint that the integrity of their design be maintained. Very often they lose in that decisionmaking process or they are not given the time to devote to making a careful study of a change that is made in the field.

I think this committee would do well to really dwell tremendously on this question of design and construction techniques during the construction phase of projects.

Mr. GORE. Well, our witnesses yesterday were unanimous in that conclusion, that is one of the keys to solving these problems that can be solved, avoiding many of these incidents that, as you say, don't have to happen.

Would you recommend that, as our witnesses did yesterday, that our uniform code be amended to require a continuing presence by the design professional by way of requiring a design professional to certify that the construction was performed in accordance with the design. A few jurisdictions now have that. Would you recommend that be a uniform requirement?

Mr. LEPATNER. Taking into consideration the cost factors involved, owners will have a significant say in this, because it is going to require substantial additional fees for the design team.

Mr. GORE. Which, in turn, are a relatively small increment of the total.

Mr. LEPATNER. Absolutely. :

I would suggest this as a very critical suggestion for implementation and I know that many architects and engineers have had con-

tract negotiations stalled in the predesign stage over this point and very often it is the cost consideration which comes to bear from an owner's standpoint.

Mr. GORE. Mr. Vince, would you agree?

Mr. VINCE. I would like to comment on that.

I think that from an insurance industry point of view, dealing with design professionals we have mixed feelings with respect to certifications.

We feel that in many instances certifications are required and that the professional who is required to give that certification simply cannot have the degree of intimate knowledge that would be required for him to certify that the building was constructed in accordance with the plans and specifications.

It is physically impossible for one or two architects or structural engineers or a team of architects and structural engineers visiting the site to examine every detail, to determine how close rebar is to the surface of concrete; to determine whether there has been sufficient rebar put in; to determine that the welds on a steel structural frame are sufficient, are full penetration welds or surface welds.

Those kinds of inspections are nearly impossible to achieve, therefore, requiring an architect or engineer to make those kinds of certifications would impose on that architect and engineer an impossible task.

I feel, however, that in the interest of the safety of structures, that the structural engineer should review the work of the contractor, should make periodic visits to the site, should make a detailed examination of sufficient portions of the structure, should participate during the critical phases of the structure such as the placement of the foundations, and the erection of the building frame. These certainly are very important and can be helpful in reducing or eliminating claims.

Mr. GORE. Well, I think I understand what you are saying. It should be done, but hopefully in a way that doesn't increase the liability of the folks that you insure?

Mr. VINCE. I think to boil it down very simply, in order to get a job well done you have to give someone a possible task. You can't commit them to an impossible task and then simply because you have committed them to the impossible task wherein they have to sign a certification which certifies something that they have not been able to verify.

This serves no purpose whatsoever.

Mr. GORE. Well, let me ask you this. Shouldn't someone verify all those items that you mention?

Mr. VINCE. I think it is important that there be a process on the construction site to inspect critical areas.

Mr. GORE. Who should do it?

Mr. VINCE. I think that it depends on the makeup of the site. I think if you have a construction manager the construction manager should do it. If you have an architect who is the prime design professional, he should delegate those responsibilities to his consultants, subconsultants, architects, mechanical engineers, and so forth.

Mr. GORE. But then be unwilling to certify that they have done it?

Mr. VINCE. I think what they would be willing to do and what we would certainly encourage them to do is to very clearly state what they did on the jobsite, what measures they took to inspect, what they observed and what areas they weren't involved with.

Mr. GORE. So long as they don't take responsibility for having done it right.

Mr. VINCE. I think they should take responsibility for what they do.

Mr. GORE. Well, who should take responsibility for the job having been done right?

Mr. VINCE. I think the contractor's responsibility is to do the work in a workmanlike manner and not to do faulty work. I think the responsibility of the designer is to properly design the structure in accordance with the acceptable standards that prevail at the time and place he does the work and to make periodic inspections of a sufficiently detailed nature to assure the owner that the project is being built in substantial conformance with plans and specifications.

I think that for an owner to hire his design professionals and then exclude him by contract from performing services during the construction process is dollar-foolish.

Mr. GORE. Well, the problem with this is that in the large modern construction project, because of liability and insurance concerns, responsibility is tossed around like a hot potato between the various participants in the construction enterprise and everyone agrees that quality control should be done but no one wants to accept the responsibility for making sure that it is done. As a result, we have these gray areas when the hot potato is in midair when mistakes are made.

Mr. Thompson, you are itching to comment on this as lawyer for this fine insurance company. Go ahead.

Mr. THOMPSON. Mr. Chairman, what I would like to do, if I may, is to ask Mr. Vince a question or two which I think would clarify the point.

Mr. GORE. Well, that is not our normal procedure.

Are you appearing as a witness or counsel?

Mr. THOMPSON. No, I am not. I am appearing as counsel. I will be glad to hold my question if you prefer that but I think I could clarify the matter with a question of Mr. Vince.

Mr. GORE. Well, we don't use that procedure. I will be glad to let you testify if you wish. I don't want to seem like a nitpicker but there are reasons for having set procedures. If you want to offer some comments we would be delighted to hear from you.

Mr. THOMPSON. If you would prefer, I would be happy to do that. I think I would make the point that as I understand Mr. Vince's testimony, it is in accord with my own understanding of Shand, Morahan's viewpoint on this subject. We are making a distinction between a certification as to certain inspections which are performed by somebody who is on the jobsite on the one hand and specific representations by the person who made those inspections which may or may not be all of the items that go into a given design and specifications for a particular project.

As I understand it, it is our position that it is a very good idea to have fixed responsibility for certain inspections but that the scope

of the inspections would vary from job to job depending upon the nature of the work being done. As Mr. Vince has said, we have mixed feelings about certifications because a certification is a very broad and comprehensive term. There is no question that the person making the particular inspection that is specified should be a matter of private contract between the owner and the design professional. There is no problem with requiring that those specific items be the responsibility of the person who has undertaken to do the inspection. The point is that there is a distinction being made between those specific findings and responsibilities and the broad gage certification of everything that Mr. Vince has characterized as really an impossible burden on the design professional.

Mr. GORE. Well, I think that is helpful but I think that it illuminates a very critical distinction between simply playing a role and accepting responsibility.

How could the public body responsible for building codes that govern a construction project affix responsibility for insuring that the construction is in accordance with the design without use of a certification tool?

How could it be done without certification?

Mr. VINCE. What I would like to comment on is that if one looks at the contracts that have been utilized in the construction field, the contracts very clearly place responsibility on the contractor to build a structure in accordance with the plans and specifications. It would seem to me that the duties of the contractor are consistent with meeting the plans and specifications and that is where the burden of responsibility should lie.

Mr. GORE. But according to the testimony we have received, it just can't work that way. You can't have a design, a blueprint, an engineering design and then turn all of that over to brick and mortar people and say it is now your responsibility to make certain that the design is adhered to.

All of the testimony from the professionals indicates that in order to make certain that you are not increasing the risk of a major structural failure, you have to have continued attention during construction on the part of the design professional. There doesn't seem to be a lot of dispute about that. You were saying essentially the same thing in your testimony. Now, the suggested change to the uniform code yesterday had a very simple objective as I understood it. It was to allow the public to establish a ground rule and say, look, we have learned at least one lesson from these major structural failures, it seems to be important for the design professional to have a continued presence to insure that the construction takes place in accordance with the design. So, in order to make certain that happens, we are not going to allow people to cut corners, owners to cut corners by pushing the design professional off the site as quickly as possible. We are going to say, because this is in the public interest this design professional has to have a continuing involvement.

That seems to me to be a good idea and the certification proposal for the uniform code was a simple manifestation of that idea.

Now I can't judge off the cuff the merits of your problems with the certification mechanism. Clearly, insurers of the people who would be doing the certifying have an important point of view to

express but it may not be determinative. Maybe it shouldn't be determinative of the outcome but that is an important point of view.

Mr. LePatner, do you want to comment on this?

Mr. LEPATNER. Well, a certification as a matter of law says that the person who is providing that certification knows from his personal knowledge that which he is certifying.

When you ask an architect or an engineer to certify the work in place as constructed by the construction team, he must be personally satisfied in order to fulfill that certification and meet a high professional standard, that he knows in fact that his design has been constructed exactly as shown on the plans.

The practical reality is that on a major project, insuring that degree of personal knowledge of every aspect of construction is almost an impossibility. And the reason is that there are portions of that project going on over a wide area. There are many trades involved and to have a design professional with the requisite amount of skill and knowledge there at every piece of sheetrock going up and every pouring and every weld is a practical impossibility and that is why a certification as a legal measure would be very difficult to impose upon design professionals.

However, from a standard of professionalism, it is practical to ask architects and engineers who have a resident inspection obligation to be familiar with certain critical phases of construction, to be aware that he should be there if he has that obligation during pourings of foundation footings. That he should be there when they are doing the first laydown of the girders to make sure that they meet specifications as they come from the fabrication plant.

He should be there to check certain materials that are critical.

Mr. GORE. Should he be asked to certify those things?

Mr. LEPATNER. If he is looking at specific things he can only certify that which he has personal knowledge of. But there is no way that when that building is completed that you can realistically expect the design professional to be assured of the entire design being implemented as it is shown on the plans and specifications except for the most simple of structures.

Mr. GORE. Well, how could you set a ground rule? First of all, do you agree that such a ground rule, broadly stated, insuring that the design professional has a continuing presence on the jobsite to try and insure that the construction takes place in conformity with the design is in the best interest of public safety?

Mr. LEPATNER. Let's restate it.

Mr. GORE. All right.

Mr. LEPATNER. To have a resident inspection obligation from a designer's standpoint is very preferable and the reason is that even after the design has been approved by an owner, conceivably the mass of those design documents could have errors in them or things that may be in need of correction or refinement.

By being onsite during construction you have what is called that last final check to pick up these types of things.

Mr. GORE. Or to examine the effect of change orders.

Mr. LEPATNER. Or to be there in case of changes or substitutions, correct. That obligation places upon the professional a standard of care that he is schooled in.

However, what you have to distinguish is between those things which are in the contractor's realm where he has the expertise. He has the sophistication. He has the experience and has the know-how to do things as a contractor, as a prudent construction man.

That is not and should not be within the realm of the architect. Knowing that there should be 8 nails or screws in that piece of sheetrock to hold that wall up should not be within the province of the architect to count the nails.

The construction man is paid for that and the architect will invariably say I can't do it. It is not part of my job.

Mr. GORE. Well, inspection services used to be much more common than they are now if I am not mistaken. There was a term called title II that referred to inspection services that engineers were quite familiar with but we find that engineers often don't get a title II inspection responsibility today.

Are we correct in that finding and, if so, why?

Mr. VINCE. I would think that you would find in the structural failures that we have talked about, I haven't done a detailed examination of each of those failures, but I think that with the general knowledge that I have with those failures, that I think that you would find that there were present on those sites professionals with a view toward determining whether or not the construction was being done in accordance with those designs.

I think that from our point of view in the insurance industry we look much more favorably upon design professionals who, as a matter of due course, insist on and generally achieve onsite responsibilities during the construction process.

We think that this goes a long way to assure that the cold, two-dimensional information that is contained on drawings and the restricted information in terms of one's ability to write that is contained in the specifications can become a three-dimensional idea when discussed between the contractor and the engineer.

We are very much in support of that contention and we believe that that is an important procedure to have in effect on a construction site.

Mr. GORE. We heard testimony yesterday that most of these major structural failures did not have an engineer onsite during construction with inspection responsibility.

Mr. VINCE. As I say, in preparation for my testimony I haven't examined specifically those projects.

Mr. GORE. You haven't examined the major structural failures?

Let me ask Dr. Pfrang, would you object to coming up and joining our witnesses? There is a chair on the other side.

You were here during the panel yesterday. For the recorder, this is Dr. Edward Pfrang, Chief of the Structures Division with the National Bureau of Standards here in Washington.

Am I correct in saying that in connection with most of these studies by NBS of major structural failures, as often as not, there was no engineer on the site inspecting during the construction?

Dr. PFRANG. That is correct. He did not have a primary residual responsibility during the construction phase.

Mr. GORE. Well, that is awfully important.

Mr. Vince, that would seem to be an important common denominator?

Mr. VINCE. Well, I have to defer to a higher degree of knowledge on that subject than my personal knowledge.

Mr. GORE. Well, we ought to take that into consideration in reviewing your testimony in that you don't think there are common denominator causes. There may be.

Mr. VINCE. That is certainly your privilege.

Mr. Chairman, could I comment on that not having a professional on the site responsible to check the work of the contractor is an element and may not necessarily be the cause of that structural failure.

Mr. GORE. Well, right after you finished your statement I said that I wanted to ask you questions about that. I very much appreciate your statement and the statistics and the figures are very, very helpful and as I said earlier, I think our differences may be one of definition but I really think it is important.

Mr. LePatner said details make or break the job. Would you agree with that?

Mr. VINCE. Yes.

Mr. GORE. The only way to avoid mistakes on important details is with rigid quality control. Would you agree with that?

Mr. VINCE. I would agree that that is an element that would act to reduce the chances that these mistakes occur, yes.

Mr. GORE. If we find a pattern indicating a breakdown in the performance of rigid quality control over important details that contribute to major structural failures that may be a generic cause or common denominator.

Mr. VINCE. As I say, Mr. Chairman, we have looked for those patterns and we believe if you could find those patterns they would be extremely helpful, yes.

Mr. GORE. Would you agree, Mr. Vince, with Mr. LePatner's statement that the increasing cost of construction is creating pressures to contract the time of construction?

Mr. VINCE. Yes. I would think that in the last 10 years we have seen an increased frequency of certain methods to do this, one of which is the fast track method of construction where you design the foundation and the structural frame. You begin constructing the foundation and structural frame while you are involved in the designing of the other structure. I am not suggesting that the fast track method is a method that should not be used or is unworkable. There are many fine projects that have been done on the fast track method that have exhibited few problems. It certainly is a method for constricting the time frame of construction.

Another method that has a lot of additional major construction has been done by design builders rather than the design team and the construction team. Where these have been combined within the same organization, the organization can control elements of design and construction.

I think you are absolutely correct, Mr. Chairman, that many of these methods were chosen in order to restrict the time. We have uncertainties in our society. Inflation is a very big factor when you have a construction process that may take place over a number of years.

The cost of future purchase of materials for that project and the uncertainties attendant therewith are major concerns and I think

that there are valid reasons within our society that methods to minimize the time in connection with building construction.

Mr. GORE. Well, I think our view of that trade-off might be very, very different if one of those four or five stadium roofs that have collapsed had collapsed when the people were in it instead of when they were empty.

Luckily, stadiums are usually empty. But if one falls in when a game is in progress you have 15, 20, 30,000 people at risk. Luckily, this hearing is taking place in a time when that hasn't happened. But look at the number of these major structures that have collapsed.

Now, the appreciation of cost problems experienced by owners is clearly an important consideration but the balance between that consideration and the urgent need to insure that a tragedy of that magnitude doesn't occur would appear very different, I think to all concerned, if this hearing took place in the aftermath of a tragedy instead of as an effort to prevent one. Of course, there have been tragedies of unacceptable magnitude like the Hyatt tragedy.

But if increasing costs are intensifying the pressure to contract the time period, the next step is pressure to minimize the role of the architect and engineer in the construction project.

Would you agree with that?

Mr. VINCE. I have nothing on which to agree or disagree with that.

Mr. GORE. Mr. LePatner?

Mr. LEPATNER. I would agree.

Mr. GORE. I think that is really the core of the problem right there.

Mr. LEPATNER. Let me add this to our colloquy on the subject. Standard contracts which are widely used for owner-architect agreements in this country provide for only what is called periodic observation by the design professional team.

Those contracts are not something configured merely at the whim of the American Institute of Architects, but they have been worked out jointly with the general contractors associations, and the Society of Engineers, and there is an ongoing review and analysis of these contract documents because of their wide use.

What must be understood is that today the construction industry and owners as participant do not opt for having onsite residential inspection. In fact, that movement away from that over the years has caused this provision in the contract documents of the design team to use the word "observation" instead of "inspection" because, since you are asked in general to appear once or twice a week at the site, you cannot properly perform an inspection which involves a detailed investigation of what is going on.

So, that word "observation" is more accurate and has become more widely used than the word "inspection."

To the extent that remains the norm, you are going to have a wide gap between what is designed and what is ultimately constructed or little assurance to protect against a discontinuity between the approved set of design documents and what is ultimately constructed.

But this is not something that the design professions have foisted upon themselves or have looked to opt out from in terms of liability.

I think this committee may well wish to address that question of these widely used contract documents and how, perhaps, some kind of balancing in this area can be corrected.

Mr. GORE. Well, if you have an architect or engineer who has a contract that calls for observation instead of inspection and that person comes to the site and sees something wrong that he is not required to inspect, is he responsible for something that has to be corrected?

Mr. LEPATNER. Absolutely. He is required, under the standard AIA owner-architect agreements, to immediately advise the owner of any patent defects. He is obligated, under other provisions, to guard the owner against deficiencies in the work and, from both a professional and an ethical standpoint, he must take immediate steps when there is any question concerning the safety or integrity of that structure.

Mr. GORE. Now, as a practical matter, if the operative term of the contract is observation, that can often lead to disputes with the builder, correct?

Mr. LEPATNER. During construction, that does occur.

Mr. GORE. So, as a practical matter, human beings being what we are, there is a natural incentive to minimize the number of disputes of that kind?

Mr. LEPATNER. I think prudent architects and engineers report these things to the owner.

Mr. GORE. When they know about them?

Mr. LEPATNER. When they learn about them. And the owner, of course, has to make a final decision.

Mr. GORE. Now, the mechanism for avoiding the number of disputes that I am suggesting occurs in not declining to report problems to the builder and to the owner, but rather in minimizing the number of problems observed?

Mr. LEPATNER. Being onsite, to observe more frequently, will enable more opportunities to detect departures from the design and have those picked up and attended to before problems can occur down the road.

Mr. GORE. Well, again, the panel yesterday indicated that it is now common practice, when the contract is worded that way, for them to go on the site with blinders so they don't go out of their way to look for and find problems or departures from the design.

Mr. LEPATNER. I have trouble accepting any prudent, responsible architect or engineer who can make that statement because, to my personal experience, the architects and engineers I have encountered take a great deal of pride in that finished structure, whether they have onsite residential inspection or whether they have periodic observation. It is their name that gets affixed to that structure as the designer of record, and no one that I have ever encountered has ever used that term, has ever passed that along to me.

And I will say this. I have also been involved in representing many of the major insurance companies, professional liability insurers for designers, and I have never heard that statement from

any carrier, any representative of a carrier, or any attorney who has represented one.

Mr. GORE. We sure heard it yesterday.

Dr. Pfrang, do you want to comment on this?

Dr. PFRANG. Yes, I was here for that testimony yesterday and I also heard it and I also hear this within the professional community.

I think that what is being referred to, in terms of the blinders is that if you have a responsibility which is set forth in your agreement with the owner then you will adhere to only that responsibility. You will not look for any problems that might be outside of your limited responsibility. That is what I think they are referring to.

Mr. GORE. Well, that is not inconsistent with what you are saying, is it, Mr. LePatner?

Mr. LEPATNER. No.

Mr. GORE. It is just a different emphasis?

Mr. LEPATNER. If you are called to the site because there is a question concerning discoloration of the concrete, I don't think most designers are then going to take the construction elevator up to the 14th floor to see if the welding is going on properly. That is not to be expected.

Mr. GORE. Well, if the design professional, obligated to observe, calls a problem to the attention of the builder, and it is not corrected, is the design professional also liable?

Mr. LEPATNER. In these situations, I believe I have never encountered a situation where an owner, who was alerted to a potential safety problem, hasn't acted responsibly and has not understood the implications of that alert.

Mr. GORE. Let's shift the focus just slightly to the problem of making information public and available to the professions in the wake of major structural failures. You brought to our attention the incident involving the Hancock building. Are you aware of other such incidents, or is that an isolated occurrence?

Mr. LEPATNER. What happens is this: These cases, after the initial reporting by the media about a collapse, about a potential problem, are rarely followed up. There is no investigative journalism in this field, nor has there been access to the actual case files because they are in the hands of lawyers and they are handled as a piece of litigation in our courts.

Very often, documents are filed in certain courts and are available to the public for anyone who wishes to do the necessary homework.

But, by and large, this source material, the expert reports, the analyses have not been made public not by any intentional act to cover up. Just the contrary. There has been no one who has made the compilation or who has gone into the digesting of this material.

When we have litigation involving corporations and litigation involving other areas of our business world, very often there are sources for reporting these things. Certainly there are trade journals. There are reporters that follow various industries, but there are none right now that follow up on the reporting of design errors, defects, and construction errors. And, what little reporting there is, is not given the attentive detail.

Mr. GORE. Well, now, in the case of the Hancock tower, what is their incentive to keep it under court seal?

Mr. LEPATNER. I do not personally know.

Mr. GORE. Really? Are there potential private lawsuits?

Mr. LEPATNER. There are one or two of the defendants in that action who have continued to fight the litigation.

Mr. GORE. Was there a settlement?

Mr. LEPATNER. There was a settlement by the major parties to the litigation.

Mr. GORE. Was it a common practice to seal the records of cases where there is a settlement?

Mr. LEPATNER. No.

Mr. GORE. Is it fair to surmise—it is always fair to surmise, I guess, but is it reasonable to surmise in this instance that concerns about the liability to the other litigants were a factor in sealing the records?

Mr. LEPATNER. Not being a party to the lawsuit, I could not begin to conjecture.

Mr. GORE. Well, it makes sense to have a wide dissemination of the causes of major structural failure. Nobody disagrees with that? Mr. Vince?

Mr. VINCE. No. I just would like to make the point that there seems to be implied here that there are a large number of structural failures.

I certainly feel as you do, any failure, such as the future collapse of a stadium that destroys a vast amount of human life, is to be avoided. I don't disagree with that. But I think if one looks at the history of building construction in the United States as your committee is doing, over the last 6 years, I think you will find that the condition that we are addressing is a rare and unusual occurrence rather than something that is commonplace.

Mr. GORE. It is almost as rare as an airplane crash.

Mr. VINCE. That is correct.

Mr. GORE. But, there we have major investigations and wide dissemination of the information involved. I grant you that these occurrences are relatively rare and I think that is a helpful addition to the record, and we made that point yesterday. But, like airplane crashes when they do occur, the risk to the public is substantial. As buildings become larger, taller and have more people in them, the risk grows. And, after all, how many of these big football stadiums have collapsed? Have there been four? Dr. Pfrang?

Dr. PFRANG. About that number; yes.

Mr. GORE. Four or five, I mean that is a lot, isn't it, Mr. Vince?

It seems to me, given the small number of stadiums in the country, to have four or five fall in is a matter for substantial concern. And, if we are going to build more of these, I hope we can get one in Tennessee, where we are trying to get a professional football team into either Memphis or Nashville. It would make sense to disseminate the information widely and that was my initial question. Improvements in the safety technology in air travel have been the direct result of the investigations conducted but the trend in major construction projects seems to be the other way.

The professionals who have testified, testified that they have seen a real slippage in quality control and a real slippage in the

safety of these structures, as long-span structures are used without a full understanding of the total stress under all conditions, et cetera, et cetera.

My question is, Mr. LePatner, Do you agree that it would make sense to have really major structural failures investigated as a matter of course by the National Bureau of Standards or a group akin to the National Transportation Safety Board that performs this function with airline accidents and insure that the results are made available to the professionals in this field?

Mr. LePATNER. I think, in my statement, I made clear that one of my strong recommendations would be as wide a dissemination of the investigative materials that come out of these collapses as possible and you do not necessarily need a major collapse to learn something from a structural failure.

I think there are many structural claims that never reach the failure stage that could be educational fodder for the design professionals and the construction industry because they play a very pertinent role in implementing the design.

I would be the first to suggest, I think hopefully some of the lessons set forth in the book will go a little bit, if not a long way, toward highlighting potential problems so that those who are in the process of designing buildings or those who are in the process of constructing, can be alert to situations that might not have come to the fore previously.

Mr. VINCE. Might I make another comment, Mr. Chairman?

Mr. GORE. Yes.

Mr. VINCE. To put this matter in perspective with respect to Mr. LePatner's remarks, I don't think, he intends to say this but I would like to see that it is said.

The mere fact that we are in a litigious climate here doesn't preclude information from getting into the hands of the people who devise the codes and develop design techniques on buildings.

I think that we just have to review what occurred as a result of the heavy snowstorms that we had I think in the winter of 1978 and 1979 wherein the Midwest and Northeast, in particular, a number of rooves failed due to abnormal snow loads.

I think that the information, the technical information that came out of the results of those failures that even though the failures were precipitated by acts of God and the loads were unusual, the performance, for example, of barrel rooves, the effect of eccentric loading on domed rooves has all added to the body of knowledge with respect to the performance of these types of structures.

And I think that in many of the failures that we have investigated in the sampling that I talked about in my presentation, much of the information concerning how a particular joint acts or how a particular beam acts under torsional stress or lateral stress or whatever, has found its way into technical journals, into the thinking of people who design codes. The mechanisms are there.

It is not that they are absent and I think that one of the things that you should consider is what mechanisms are there and what improvements, do you feel, to the existing mechanisms you might wish to contemplate.

Mr. GORE. Well, I think that is helpful and I particularly like the specific suggestions in this regard that Mr. LePatner had that the

AIA and others should have seminars, the trade professional journals should do a better job of investigating and reporting the causes of incidents and that the schools of architecture should incorporate the case study method of structural failures but I think that it is also necessary to insure that information is publicly available when these incidents occur. And as we have heard that often is not the case. What seems necessary is an impartial, speedy investigation, thorough investigation, of major structural failures and a central repository for the information gleaned from those investigations so that we can avoid a recurrence of such incidents.

Is it fair to say that the quality control procedures in the construction industry fall far short of what one might find in aerospace, for example? Maybe that is a leading question.

Mr. VINCE. I have no idea what the standards are in the aerospace industry.

Mr. GORE. I am sorry to take so long with this first panel. It has been very interesting and I appreciate your participation and I thank you very much.

Our final panel is made up of four witnesses, Mr. Jim Crozier, executive vice president of the Quadrangle Development Corp. here in Washington; Mr. Randy Vosbeck, principal with the V.V.K.R. Co. in Alexandria; Mr. John Archer, chief civil engineer with Burns & Roe in Ordell, N.J.; and Mr. Key Hickman, chief estimator of the Volpe Construction Co. in Suitland, Md.

Gentlemen, I would like to welcome you as witnesses. Gentlemen, without objection, your entire statements will be put in the record in full.

We would like to begin with you, Mr. Crozier. If you care to summarize any portion of your statement, that is fine with us.

Welcome and please proceed.

STATEMENTS OF JIM CROZIER, EXECUTIVE VICE PRESIDENT, QUADRANGLE DEVELOPMENT CORP., WASHINGTON, D.C.; RANDY VOSBECK, PRINCIPAL, V.V.K.R., INC., ALEXANDRIA, VA.; JOHN ARCHER, CHIEF CIVIL ENGINEER, BURNS & ROE, ORDELL, N.J.; AND KEY HICKMAN, CHIEF ESTIMATOR, VOLPE CONSTRUCTION CO., SUITLAND, MD.

Mr. CROZIER. Let me just paraphrase. As you said, I am a developer of commercial buildings in Washington, D.C. I would like to draw upon that experience and talk about the role of the developer and the developers' business practices as they relate to structural failure.

I would like to start out by saying, Mr. Chairman, I am not an expert on structural failure and I sincerely hope never to become one. But we all are concerned with structural integrity, everyone in the building process is.

The night of the Hyatt catastrophe was a very wrenching one for people who were designing and developing hotels in other parts of the country. These failures are infrequent, but they are catastrophic and we all must be conscious of safety.

The big concern I have in this respect is the total number of people who work on a project is incredible. Sitting here listening to the other testimony and looking around the room at the space pro-

gram and the number of managers and the number of people involved in getting one of these things up, I can't help thinking how they relate to some of the big complicated downtown projects. They are just as complicated. But the management skills and management techniques for running those projects are not at all comparable to what you find in the space program.

Your earlier comments sounded like we are all looking for one thing that we are doing wrong technically. My guess is that most of the problems with failure come about through a failure in management and pretty much management of the design process.

Mr. GORE. I would agree with that.

Mr. CROZIER. I am going to skip ahead here since we have only a little time. Incidentally, in Washington, D.C., in my memory and the memory of my colleagues, there have been only three failures. All those three failures have been on projects under construction. I know you don't want to speak about that today, but I believe that there are lessons to be learned from projects under construction and I would like to talk about that later on.

Mr. GORE. That is fine.

Mr. CROZIER. As for the developer's role in this matter, I think there are four major areas where a developer exerts considerable control and that is in selecting a design firm, selecting the contractor, determining design and construction budgets and then setting occupancy and use rules for a structure after it is up.

I want to talk about that as well.

I think there are things that a developer does that help isolate him from structural problems. First off, Mr. Vosbeck won't like this, but he has heard it before. We are not interested in structural exhibitionism or in a vanguard structure. What the developer likes is what worked in the past.

We like tradition. We like repetitive work. The critics say we like work that is too repetitive but it comforts me.

Also, the developer is not normally limited to a one-building career and I think some of these buildings you talk about are built by agencies who have the function of designing one building and then, in effect, going out of existence.

Second, the developer shies away from special-purpose and unique buildings. So he is helped a little bit by what he chooses to go about in terms of his work.

Incidentally, I think Washington, D.C. sets a sort of special case for structural safety. Our low height limits, the maximum in a very small portion of town is 160 feet.

It sort of argues for concrete structures. I don't think concrete is inherently more stable than steel, but if a concrete structure is going to fail, it gives an awful lot of warning. It gives warning for years in terms of cracks and noise and all the rest of it.

Mr. GORE. We found in our investigation that a disproportionate number of structures involved were steel structures.

Mr. CROZIER. Because, in steel a failure would usually be instantaneous, where concrete gives a lot of notice and it is an inherent benefit of the low-height limitation in the District of Columbia.

In terms of selecting the design team, in a conventional manner, the designer usually selects the architect who would then select the structural engineer and mechanical and electrical engineer.

Lately in Washington, and perhaps in other cities, the developers are selecting the architect and then selecting their own structural engineer and then selecting their own mechanical and electrical engineer. It did not come about because of a concern for structural safety, but because that process makes each engineer work for the owner. You open up lines of communication that are not normally present when your owner works only with the architect. This way, it is possible for the engineer to call us on the phone and say, we have got a real problem here with this design, don't tell the architect I told you that, but we have a problem with the design.

Opening up those channels I think is very, very important for the owner, developer to know what is going on. It puts the developer in a slightly higher position relative to structural safety, but if something happens to a building, ultimately it is the developer who is going to take the responsibility for it, so he might as well pick the man he wants.

Mr. GORE. Let me interrupt you there and offer my apologies, but we have these two significant votes on the floor. We will recess for between 10 and 15 minutes and I ask your indulgence and we will get under way when we come back.

[Recess.]

Mr. GORE. The subcommittee will come back to order.

I apologize for the delay. We had two votes on the floor and, Mr. Crozier, you were in the middle of a very interesting statement.

Mr. CROZIER. I was saying that the first chance that a developer gets in influencing structural safety is in the selection of the design team. Today, more and more and more, we see developers selecting each individual member of the design team, instead of just picking the architect. This, we feel, opens up chains of communication between the design team members and the owner/developer that we find very useful. In addition to that, when we look at individual design team members, and I am talking from a developer's standpoint, we look for track record, experience and especially experience with a particular type of building that we are interested in.

We also want to know if the design team member's appointment gets the concurrence, if not the approval, of the general contractor.

People don't talk about this very much but most of the time, the general contractor has an influential vote on the design team members. I have worked with him before. He says I like him, I don't like him, et cetera, et cetera.

I believe that this shows the byproduct of this is that the contractor, in the development project, is involved very early, whereas in certain other projects, the contractor does not come in until the design is complete.

We also want design work to be based on nuts and bolts as I said in my statement, not on high tech. What I mean is that the phrase, "state of the art," makes people like me very nervous. What we are interested in very early in the design, is to know what the cost of the project is going to be and if the project is state of the art or high-tech design, we can't get an accurate cost estimate so we stay away from it.

I think again a byproduct of that approach is that our buildings are put together by traditional methods. It does not mean that we don't have problems. We have had them.

We also have to alert the design team to the fact that there are always last-minute changes in designs. It is just a fact of life. The insurance companies want them; the building inspectors want them; the owner wants them to cut costs and the 3 or 4 months before a building is actively under construction is a very feverish time for making these changes. They just happen and they are a part of life. But you have to select your design team members from persons who enjoy that and feel that that is important. What we are not looking for is the early bloomer who likes the original design, but then wants to quit when things get tough.

Our selection process consciously or unconsciously screens out unproven design team members and also screens out unproven design concepts. A negative byproduct of this approach is that we are afraid that the individual design team members may not want to rock the boat. They want to get selected for the next job so they don't want to bring up unpleasant things. Our job is to encourage an environment where we, in effect, almost promote controversy during the design stage because then we know we are handling substantive matters. But if the design stage is too smooth, too laid back, then we have problems.

Also, as somebody indicated earlier, we cannot have such a ridiculous timetable that the design team does not have time to do their work.

The next area where we influence structural safety is in selecting the contractor. It would be a rare instance that a developer would select a contractor by competitive bid. We bring him in early. We talk to him and select him for other reasons. I think that the competitive-bid approach, while many agencies have to use it, can result in a guy bidding too low and being forced to cut corners in the construction process. Those corners that are cut then can produce latent defects that we find 5 and 10 years down the road. So I think we are fortunate that we are not forced to select by competitive bidding. We select, hopefully, for prudent business reasons. The size of the firm, his experience, his track record and safety record.

I think all those things tend toward a cautious attitude toward safe construction practices.

I think another area in which the developer is influential is in determining budgets, both design and construction.

I heard in an earlier statement here about the structural engineer. One thing I think that has to be done is to break up these terms that people are using, saying design professional, and I am not sure what they really mean. They say a design professional should do this or should do that. I think it is fairer to say architect, structural engineer, mechanical and electrical engineer.

It might be more difficult to say that but we would prefer to do it that way. We believe that the structural engineer has a vital role to play in ongoing inspections in the field as to what is done. Actually, the buildings are built to a great extent from the structural drawings. We take our structural engineer, and in the testimony I hear we have increased his fee in general by as much as 50 percent to do daily inspection in the field, to see that the structural design is in accordance with what we want it to be.

Incidentally, as an owner-developer we also have our own people in the field who are there on a day-to-day basis to find out what is going on. They don't have the technical expert knowledge in terms of the placement of rebars and all those other components a structural engineer has to check, but we are vitally interested in seeing that happen.

We are not the saint in terms of precluding the architect from going to the field. Typically, we express a certain disinterest in having the architect come to the field on an inspection basis and I think I can talk about that better in answer to questions.

Mr. GORE. Yes.

Mr. CROZIER. Our structural and field inspector who works for the structural engineer, his inspections are carried out in addition to those that are carried out by the building inspector and, therefore, give us additional coverage or supplement.

We had a project on Pennsylvania Avenue and we were quite concerned about the safety, not of our own building but we were quite worried about the National Theatre and National Press Club which were adjacent to our project on the other side.

What we did was sort of turn the situation around and we hired a firm who was extremely well skilled and well thought about nationwide in terms of accident investigation, that is, investigations of what happened after it happened. We brought that firm in to come up with a series of scenarios on what could happen to the Press Club and what could happen to the National Theatre. I can tell you, Mr. Chairman, that all those scenarios are very harrowing and on the basis of those scenarios we came up with a series of steps that we could use if certain things happened to either the Press Club or the Theatre or to both and then we devised a daily, weekly and monthly monitoring system that included gauges and devices that I am not even sure I can either pronounce or understand. But they were in there to find out if there was any movement in the Press Club and the Theatre and how much movement in those buildings while we were underway.

So far, so good. At least I haven't had any telephone calls this morning. But that alone increased the amount of money we set aside for structural design fee by a factor of four. In this case we were able to afford it. In this case we had to afford it. Nobody forced it on us. It was voluntary but I wonder if every person in that same circumstance would have the budget flexibility to do that.

It could very well be, Mr. Chairman, that one thing we have to concern ourselves with is that the building codes more properly provide not only for the building under construction but as importantly, the buildings next door which also have to be protected.

We also heard earlier about construction budget. Developers learn early on that there is no sense trying to save money on the structure. Structure in this town is about 25 percent of a building's cost and if you save 10 percent on structure, which would be an awful lot of money, you would save 2½ percent of building cost and of the total project cost you would save about 1 percent.

So it is not in structures that a mercenary developer, as we are pointed out to be, tries to save his money. He cuts costs in other places. Structure is one area that the developer very rarely tries to

influence or wants to influence and it has such a small impact on total cost that it is not an important area.

Another item is sort of an interesting one: occupancy.

After the building is safely constructed and we have gone through all these hurdles there are still things that tenants can do. In an unnamed building here in town occupied by a Federal agency, the agency converted the parking garage to a paper storage facility without telling anybody.

I guess the paper was needed for all those regulations. But as these engineers will tell you, paper weighs an awful lot more than cars and there was incipient structural damage done to the building. Somehow, somebody found out about it and said that this may not be a good idea, and they brought in the architect.

The point is, our commercial leases say you can't make structural changes to a building without telling us and we have to approve it. Our leases also say you can't do things with floor loading, change it, but my guess is that the inspection procedures in those leases to prevent against those kind of abuses and in this case an illegal conversion of a space are not adequate to stop this kind of thing from happening.

Fortunately, in this case we had a concrete building so that the evidence of failure was seen early when cracks had developed and people could look at them.

If that were a steel building and had been loaded that way, I am not sure that the same early warnings would have been given.

As I indicated earlier, the most important step that I can take in terms of building safety is how I go about selecting the design and development team.

I would like to amplify that a little bit after listening to the testimony this morning. It is not only important as to how I go about selecting the team but it is very important as to how I manage them.

I think that we could learn by the failure of a rivet someplace and while I think that is a shame, it doesn't bother me. What I would like to know is what was the breakdown in management skills and organizational schemes on these projects around the country.

It boggles my mind to hear Dr. Pfrang say that there were no inspectors on some of these jobs. I find it incredible.

People like us, developers, want to know not only that the concrete failed but what was the organizational failure that led to the concrete failing in the first place.

So, I think, as a leader of the development team, we are very interested in structural safety. We think that prudent business practices lessen the chances for it, but they still occur.

We are very appreciative of the light thrown on the subject by this committee. We think that you will help raise the good developer's level of consciousness to structural problems without forcing us to learn from bitter experience.

I thank you very much and I am available for questioning.

[The prepared statement of Mr. Crozier follows:]

Committee on Science and Technology

U.S. House of Representatives

STRUCTURAL FAILURES

I am James Crozier, Executive Vice President of Quadrangle Development Corporation. Quadrangle develops commercial buildings in Metropolitan Washington. I will draw upon that experience in describing both the role of the developer and developer business practices which affect the safety of a building and its occupants. I am not an expert on structural failure and I sincerely hope never to become one.

Structural integrity is of great concern to everyone involved in the building process. Failures happen infrequently but the results can be catastrophic. Therefore, everyone concerned with the total development effort, and there are many such people, must be conscious of safety.

The developer, though not possessing engineering or technical skills, as a major player in the development team must be concerned with the structural safety of a building from the construction period, a very critical time, through ultimate occupancy and use. The impact of a structural collapse must also be considered with respect to potential damage to adjacent buildings. At a later point, I will tell you of a program we devised for the protection of the National Theatre and the National Press Club while we proceeded with a major construction project on Pennsylvania Avenue.

I understand that this hearing will not focus on failures that occur during construction; however, there are lessons to be learned from such failures and these lessons will be touched on below. Furthermore, in the Washington Metropolitan area, to the best of my personal recollection, and the recollection of some of my colleagues, the three instances of structural failure that have occurred have all occurred during construction.

Developer's Role:

The developer's role in structural safety with respect to his own and nearby buildings, occurs in the following work area:

- Selecting the design team;
- Selecting the contractor;
- Determining design and construction budgets;
- Setting occupancy and use rules.

Before discussing each of these areas, it should be noted that certain areas of the developer's business practices are likely to encourage structural integrity. For example:

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- In most cases, the developer would prefer to be associated with a traditionally designed building from a structural standpoint, rather than be associated with structural "exhibitionism". What has worked in the past is more comforting than what may work in the future.
- Normally, the developer is not limited to a one-building career or is concerned with special purpose buildings. Buildings that have experienced significant structural problems are, in many cases, produced by one-building developers or are special purpose and unique buildings.

Incidentally, Washington, D.C. also presents a special case in terms of structural safety. Because of its low height limit, it encourages concrete structures which normally give advance notice of forthcoming structural problems. The building might collapse while in use, although this is unlikely, but occupants would have "early warnings" of potential trouble.

Selecting the Design Team:

The process of selecting the design team gives the developer a strong early role in the concern for safety. In the conventional manner, the developer selects the architect who then selects other design team members. However, the developer may, as increasingly seen in commercial development, select each design team member individually (i.e., architect, structural engineer, mechanical and electrical engineer). This latter course of action means that the developer, by individually selecting the design engineers, opens up individual communication channels with each member of the design team. This procedure, although not originally intended to directly promote structural safety, in my opinion, indirectly achieves that result.

In selecting the design team, the commercial developer looks for numerous attributes. Of those attributes, the ones that reflect on safety includes:

- "Track Record"; experience - especially with the type of building to be designed.
- The ability of the design team member to receive the concurrence, if not the approval, of the general contractor, as to his appointment. In short, the general contractor has a strong early involvement in planning which also, across the board, stimulates a concern for safety.
- Design work to be based on "nuts and bolts" rather than "high tech". The developer's primary motivation is to receive early definitive cost estimates, against a minimum of design fees. However, building safety is enhanced as a by-product of

this approach.

- The design team's understanding that they will be required to make "last-minute" changes mandated by code reviews, design team inspections (city and otherwise), lenders and field conditions in a comprehensive manner so that structural integrity is maintained. These "last-minute" changes are regrettable but a fact of life.

As a result of this selection process, the developer, consciously or unconsciously, screens out new any unproven design team candidates and design concepts. Another result of this screening process is that individual design team members may take a "don't rock the boat" attitude in design deliberations in order to increase their chances of being selected for the next job. This is a major concern because too much harmony among the team members may mean that controversial matters are not being addressed during the appropriate design stage.

In my opinion, the first decisions are most important and decisions made by the developer in connection with the selection of the design team, and in allocating sufficient time for their efforts, are among the most important steps leading toward structural safety.

Selecting the Contractor:

In selecting the contractor, the developer is normally not required to select by competitive bids. The competitive bidding process, while a necessity in some instances, can result in the selection of a contractor who has bid too low and who now must cut corners to bring the job home under the bid. Since structural problems are frequently created during the construction period, "cutting corners" can lead to problems.

Again, as in selecting the design team, the developer selects a contractor for prudent business reasons (experience, size and safety record), but these business reasons should also produce a cautious attitude with respect to safe construction practices.

As in the selection of the design team, the intelligent decision making process that leads to the selection of a general contractor on merits is an important step toward achieving structural safety.

Determining Budgets:

In establishing design and construction budgets, the developer must have the experience to understand the total financial commitment required. For example, the initial design budget for structural engineering alone must be increased by at least 50 percent to account for daily field supervision of construction activities by the structural engineer. The concern here, of

course, is not only to eliminate problems that may occur during construction but to eliminate latent problems that may appear when the building is in use.

In this city, these inspections are carried out in addition to those carried out by city building inspectors and, therefore, brings a higher degree of coverage to the inspection process.

We are, as indicated earlier, building a major project on Pennsylvania Avenue. We were very concerned with safeguarding the nearby structures, including the National Press Club but especially the National Theatre which is an older building and one in which repairs and maintenance expenditures have been minimal.

In this case, we added an engineering firm skilled in the investigation of structural mishaps to our design team. We asked the engineers to do "worst" case scenarios of potential problems, to design alternative structural support systems if the "worst" should happen, and to devise a monitoring system, with daily, weekly and monthly readings to determine if the "worst" was about to occur.

So far, so good. But, this monitoring program has increased the structural design fee by a factor of four. In this case, we were prepared for this expenditure. But, perhaps, other developers would not be similarly prepared.

As to the construction budget, developers learn early that "savings" on structure produces a limited impact on the "bottom line". Structure is about 25 percent of the building cost for a D.C. office building. A "savings" on structure of, say 10 percent, which would be a very major savings, would produce 2-1/2 percent decrease in construction cost and a less than 1 percent decrease in development cost - a tough way to cut a budget.

Occupancy:

Even after a building is safely constructed, structural peril can still be encountered.

A case in point was experienced here in Washington at an unnamed building occupied by a federal agency. A portion of the building, originally designed as a parking garage, was converted to paper storage. The extremely heavy weight of the paper (for all those regulations) as compared to automobiles, was beginning to cause structural damage before this conversion process was halted.

The typical commercial lease prohibits a tenant from making structural changes to a building without the consent of the landlord, and from violating stipulated live load specifications. However, I am not sure that most commercial leases adequately provide for inspection for potential violations of these provisions.

Summary:

As previously indicated, in my opinion, the most important step in the process of achieving building safety is involved in the initial selection of the design and development team.

The developer's role, as leader of the team, is very important in structural safety. Prudent business practices will, normally, lessen the chances for structural failure, but failures may occur. Therefore, light thrown on the subject by the Committee will help raise the good developer's level of consciousness to structural problems without forcing the developer to learn from bitter experience.

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Mr. GORE. Well, thank you very much. We appreciate that. We will hold questions until the whole panel is finished.

Our second witness is Mr. Randy Vosbeck, principal of VVKR, Inc., in Alexandria. Mr. Vosbeck, we are glad to have you, and welcome.

Mr. VOSBECK. Thank you, Mr. Chairman. It is a pleasure to be here.

I will start by saying I wish our developer was like Quadrangle. It is good to hear some of the things that they are doing and it would be great if that were commonplace.

I am from Alexandria, Va., right nearby, and I am a principal in an architectural and engineering firm and am the immediate past president of the American Institute of Architects.

Last year, when I was president of AIA, was the time of the tragedy in Kansas City, and so, as the profession's representative during that time, it was a trying period for me. And I watched with a great deal of anguish the reaction from the design professionals that were involved in that particular incident.

Earlier this morning, somebody commented about the record of the design and construction, industry, and I would like to start off by just mentioning that. I think our record is pretty remarkable when you consider that billions of square feet of space are constructed every year and the amount of really major failures are extremely small in comparison to the billions of square feet of space but that certainly doesn't excuse it.

And so, I think it is great that your committee is taking this initiative to look into these kinds of things, because I think the design professionals, the architects and the engineers, are truly concerned about those few major incidents that have occurred in recent years.

Mr. GORE. We will stipulate that you make fewer mistakes than Congressmen do.

Mr. VOSBECK. I think the building design professionals, architects and engineers, are really achieving some spectacular things these days. We have computer capabilities. We have a whole host of sophisticated materials and methods. We are able to design almost any kind of innovative structure that somebody says they would like to see.

We are finding that design professionals in the construction industries from around the world are really looking to us for leadership more and more. I think this country is really in the forefront of innovation and design and construction techniques.

But, with these few failures that have prompted you to look into this subject, it certainly, I think, is placing the design profession in a position of really examining how they are using some of these materials, some of these new techniques.

I think most of us recognize that we have some very awesome responsibilities. We are under immense pressure, because of time and costs and liability these days. Escalating construction costs require that a project must be built rapidly. We must move it along. We can't procrastinate on it. Time is money and we hear that all the time from the building owner.

This economic pressure has created a lot of new delivery methods for the construction team. The old traditional route of the architect

and the engineer and the owner and the contractor and their traditional formats really don't appear much, anymore.

We are hearing such terms as construction management, fast track construction, overlapping phases of construction, design built, and even the term developer, multiple prime contracts. All of these have swept into our vocabulary just really in the recent past couple of decades.

There are now many more players in this whole process. Lines of responsibility are blurred much more than they used to be.

I don't want to give you the impression here that these new methodologies have no place in the construction process. Certainly, as someone pointed out this morning, they have provided the construction industry with many outstanding examples of a quality product. But, I must stress that we must have a different type of procedure, more rigorous procedures, particularly during a construction phase with many of these new processes. Problems will continue to arise if the construction inspection and testing, and I emphasize testing, procedures are not intensified and dramatically improved when these new systems are used.

Usually, these days, and it sounds like you heard a lot yesterday, the architect has much less of an opportunity to observe construction activities. Often, the owner would say, "Why should I pay the architect to perform this service, when I have got a construction manager on the job?" And, developers may say, "Why should I have an architect or engineer perform inspection services, when I have my own professionals there doing that kind of thing?" Or, the contractor may say, "Why should I have this welding X-rayed, when I know that I have competent welders on the job doing that work?"

Everyone is under pressure to speed up the process, and this often creates a lack of attention to details and sound construction practices.

In my view, with the design professional's role during the construction phase being minimized, as it is oftentimes these days, the result can only be problems which will lead to potential failures.

As much as I hate to admit it there is no such thing as a perfect set of plans and specifications. Therefore, the architect and engineer must be involved during the construction process so that they can interpret and develop the specific details to solve a particular situation that may arise.

They need to be available to check and coordinate the various construction activities. The architect and engineer are not available during the construction process, the construction personnel, or the owner can make an incorrect interpretation of the plans or substitute a product or procedure technique that doesn't seem to be important at the time but they can make this substitution without the architect's or engineer's approval.

Obviously, unnoticed and unapproved changes in the design and construction plans lead to defects and failures.

But to mention quality control a little bit, particularly quality control as it relates to in-house, in the architect's and engineer's office. I think most A/E's have become vitally aware of the importance of quality control procedures in their offices.

We are reminded of it by our insurance carriers quite frequently, particularly with what is happening in liability matters these days, I think most of us are really concerned about how we go about checking the documentation before it goes out to a contractor for bidding.

Many of the larger and more sophisticated A/E offices now have separate quality control groups within their offices that check and coordinate their designer's work.

Oftentimes we will even go outside of our own offices on a particular unique situation and have our work checked by another group. But these procedures cost money and in the marketplace today many owners are requesting stripped-down kinds of services.

Mr. GORE. Kentucky Fried Building.

Mr. VOSBECK. Right. That is one of the first things that go, I think, in a typical A/E service is the high level of checking and quality control.

I would like to mention a little bit about building codes and building officials. While most building codes in the country today I think are more than adequate to assure structural safety from a design standpoint, the interpretation and enforcement of these codes varies dramatically from area to area.

It is rare these days to find a building official who is a registered professional, for example. Many building officials are underpaid or lack an adequate staff to provide a thorough analysis of a proposed project. Many of them rely upon the architect putting a stamp on those drawings and saying if the architect says it is OK, I can approve.

Consequently, there is often only a minimum amount of checking done prior to issuing the building permit by the building official.

Once the building's construction is underway many building officials do make periodic checks of the construction site. However, these followup inspections are usually cursory in nature and often completed by the nonprofessional-type building inspectors.

Mr. GORE. May I interrupt you there?

Mr. VOSBECK. Sure.

Mr. GORE. I think Mr. Winn asked this question yesterday.

Do you find corruption to be a major problem with respect to codes and codes enforcement?

Mr. VOSBECK. No, I do not.

Mr. GORE. OK.

Mr. VOSBECK. On the positive side of codes and regulations, I think we are beginning to see many more jurisdictions starting to require independent testing of structural elements and systems.

In my opinion this is a very commendable practice and should be encouraged especially with the fast track and compressed construction procedures. Independent testing of welding, concrete, steel and so on.

Workmanship, the materials and methods and techniques that are used in the construction process have improved dramatically and have become much more sophisticated of late. Just in the past decade we have seen the development of high strength steels, prestressed concrete, post-tension construction and such kinds of systems and materials. Better design tools and elaborate computer

programs can now calculate almost any kind of loading or stress or problem that you have got.

We have got better scheduling, better cost control techniques to aid in this project delivery system that we are all concerned about. But, and a very large but, my practical experience shows that workmanship in the field just has not kept pace with the materials that are now available and the techniques that workmen now have available to them.

If you have had a plumber or electrician to your house recently to do a home repair you probably understand what I am talking about.

I think to counteract this trend requires more supervision, more observation, more testing during the construction phase, all of which add to the cost of construction.

Last, let me just touch for a minute on the thing that you have touched on quite a bit in the earlier panel and that is professional liability. This is a very serious problem in this country today as it relates to the construction industry.

This litigious society of ours has design professionals all bound up. I don't think we sense the blinder approach that you were speaking of earlier but we do sense the caution in the way we perceive and the way we proceed through a construction phase of the project.

It wasn't too many years ago I would go out on a construction site and if I would see something going on that I didn't like I would shut the job down as the architect and I wouldn't have any qualms about it and that was an accepted procedure.

Nowadays, I think an inspector on the job just doesn't dare do that because of the impact on the schedule, on other things that might happen. And so you are really walking on eggshells. You have that impression because of all of the potential problems that can occur.

We are spending more and more time on the frivolous suit aspect of the business. It is taking a great deal of our time and so, consequently, we are more and more cautious, I think, about the way we proceed.

Mr. GORE. What would happen if you did that today when you have time pressure and you see something going on that would have caused you in the past to shut it down? Today you feel that pressure not to shut it down.

Suppose you do? What is it that you have to be concerned about, claims against you?

Mr. VOSBECK. Yes, you have got to make sure that you are right, obviously, not just an impression.

Mr. GORE. It is going to be taken out on your contract by the builder?

Mr. VOSBECK. Sure. You run the risk of a claim from the contractor on slowing down his schedule. He is under contract to the owner to produce the job on time and those kind of things as well as the owner.

Just in passing before I conclude, I would like to mention that hopefully the design professionals one of these years can convince Congress to adopt a bill like H.R. 248 which has been before you which would, I think, greatly ease some of our concerns with

regard to professional liability unrelated to structural problems but nonetheless it would, I think, tend to ease that concern.

Mr. GORE. What is that bill?

Mr. VOSBECK. H.R. 248 allows the professional to set up a tax exempt trust to take care of the deductible portion of his insurance. More and more we are having to set aside large amounts of money because we must have high deductibles, you see, in order to afford professional liability insurance and this allows us to set aside in trust a certain amount.

Mr. GORE. I am sorry to interrupt you. Go ahead.

Mr. VOSBECK. As I mentioned initially, I think the construction industry does have a pretty good record but that certainly doesn't preclude us wanting to be better.

Certain current practices are increasing the chance of construction-related problems. What we must be careful of is that we do not create so many codes and regulations and requirements that designers will be inhibited or deterred from innovation and creativity.

I think we must encourage the design profession to use new materials and use new methods and to be innovative in their design. To advance the state of the art, if you will, Jim, in such a manner that it will provide a safe environment for the users.

I think we have got to really be careful there. We do need research and we do need better information and we do need better communication to the design professionals. I think these are the appropriate paths to follow if we are to assure that the bright and creative designers are motivated and are engaged and not stymied by regulation and burdensome codes.

I thank you for this opportunity to express my views and I look forward to participating in the questioning.

[The prepared statement of Mr. Vosbeck follows:]

PREPARED STATEMENT BY R. RANDALL VOSBECK

INTRODUCTION

Good morning, my name is R. Randall Vosbeck. I am a practicing architect from Alexandria, Virginia, and a principal in the firm VVKR Incorporated. Our firm is known for its educational, medical, and criminal justice facilities as well as for its commercial building design. I have been practicing architecture for over 25 years. I am also the immediate past president of The American Institute of Architects. VVKR also has a reputation for energy conscious design.

I am very honored to have been invited to appear as a witness before this Committee. From both a personal and professional position, I'm glad to see that you have taken up the subject of structural failures. I was the president of the AIA when the tragedy in Kansas City occurred. It was a heartfelt tragedy for me, both as the AIA president and as a design professional I watched the anguish of my fellow architects and the immense suffering of the victims of that tragedy.

My oral statement is short. I will summarize some of my own observations on the design process as I believe they apply to structural failures. I hope my real value to you is the answers that I am able to provide during the question and answer period.

The Safety Record of the Nation's Building

The nation's architects are achieving spectacular feats in architecture and engineering these days. With computer capabilities

and other sophisticated procedures, these design professionals are able to design almost any kind of innovative structure. Consequently, all the nations in the world look to the United States for design and construction leadership. None the less, those few major failures are still far too many. I applaud this Committee for attempting to find out more about the causes.

Coupled with escalating construction costs, pressures on the design and construction team to produce the project as quickly as possible have increased dramatically. This economic pressure has created new delivery methods for the design and construction team. It has altered the traditional relationships among the building owner, architects, engineer, and contractor. Such terms as construction management, fast track construction, overlapping phases of construction, design build, developer and multiple prime contracts have swept into the vocabulary of the construction industry.

Now, there are many more players in the construction process. Often there are no clearcut lines of responsibility within these new design and construct systems. I do not, however, want to give you the impression that these methodologies have no place in the construction process. To the contrary, they have provided the construction industry with many outstanding examples of a quality product. I would, however, stress that we must have more rigorous procedures for professional inspection and testing when we use these new systems. Problems will continue to arise if the construction inspection procedures are not intensified and dramatically improved when these new systems are used.

These days, the architect has less of an opportunity therefore, to observe construction activities. Often the owner will say "Why should I pay the architect to perform this service when I now have a construction manager on the job?" A developer may say, "Why should I have the architect or the engineer perform inspection services when I have professionals on my staff?" Frequently the contractor may say "Why should I have this welding x-rayed when I know I have competent welders on the job?" Everyone is under pressure to speed up the process. This creates a lack of attention to details and sound construction practices, which then leads to an atmosphere conducive to construction problems and failures. More and more, the design professional's role during construction is being minimized rather than being increased. In my view, this can result in many potential problems and failures.

There is no such thing as a perfect set of drawings and specifications. Therefore, the architect and engineer must be involved during the construction phase so that they may interpret and develop specific details to solve a particular situation. In an effort to reduce fees and time, many architects and engineers attempt to cut back on detailing and leave much of the detailing requirements to the suppliers, fabricators and manufacturers. When this takes place, the design professional must be available to check and coordinate these kinds of details. When the architect and engineer are not available during the construction process, construction personnel can make an incorrect interpretation of the plans or can substitute a product, procedure or technique.

without checking with the architect or engineer. Obviously, unnoticed and unapproved changes in design and construction plans are often causes for defects and failures.

Many of the larger and more sophisticated A/E offices now have separate quality control groups within their offices that check and coordinate their designers' work. Some offices even ask another office to check their work. However, these procedures do cost money. In a depressed market such as we are experiencing now, an architect is forced to be highly competitive with his fee proposal. This means that such things as a high level of plan checking is likely to be eliminated. In addition, as I previously mentioned, many developers now eliminate any architect or engineer involvement during the construction phase from the A/E scope of work. This practice has a dramatic impact on the quality control.

BUILDING OFFICIALS, CODES AND PERMITS

While most building codes in the country today are more than adequate to assure structural safety, the interpretation and the enforcement of these codes varies dramatically from jurisdiction to jurisdiction. It is very rare these days to find a building official who is a registered professional. Many building officials are under-paid and lack an adequate staff to provide a thorough analysis of any proposed project. Consequently, there is often only a minimum amount of checking done on a plan for a major facility prior to the issuance of a building permit. Once the building's construction is underway, many building officials do make periodic checks of the construction site.

However, these follow up inspections are often cursory in nature and often completed by non-professional building inspectors. On the positive side, my firm is beginning to see many codes requiring more independent testing of structural elements and systems. In my opinion, this practice is commendable and should be encouraged, especially with the "fast-track" or compressed construction procedures.

The Quality of Workmanship is Declining

The materials, methods and techniques used in the construction process have improved dramatically and become more sophisticated in the past two decades. Better design tools and elaborate computer programs to calculate almost any type of loading or stress have become commonplace. Better scheduling and cost control techniques also aide in the project delivery system.

My practical experience indicates that, in general, workmanship in the field has not kept pace with the materials and techniques that the workmen now have available to them. I feel that this is true not only with the construction worker on the job, but also with the factory worker producing the construction product. To counteract this trend requires more supervision, more observation, and more testing during the construction phase -- all of which add to the cost of construction.

CONCLUSION

I have attempted to point out a few of the things that I feel are currently impacting construction problems, defects and failures. As I mentioned initially, I think that the construction industry

has a remarkable record. However, certain current practices are increasing the chances for building failures and construction-related problems. What we must all be careful of is that we do not create so many codes, regulations, and requirements that designers will be deterred from innovation and research. We must encourage the design profession to use new materials, new methods and innovative design techniques. We must take care to advance the state of the art in such a manner that it provides a safe environment for the users of the facilities that designers create. However, we must proceed with caution. Research, better information, coordination and communication are appropriate paths to pursue.

Mr. GORE. Well, thank you. It is excellent testimony.

I would like to call now on Mr. John Archer, Chief Civil Engineer with Burns & Roe in Ordell, N.J.

Mr. ARCHER. Thank you, Mr. Gore, for the opportunity to voice some concerns that have bothered me for some time.

I would like to mention that in my work with Burns & Roe we are involved in the design and construction of, among other things, nuclear power plants where the quality is of paramount importance and emphasis.

We are also involved in very conventional coal-fired power plants where economy of construction is of paramount importance.

I regret to say that we don't think, at least in my personal opinion, that the quality is a great deal better in the nuclear power plants than it is in our more conventional work.

Perhaps that is a self-serving endorsement of our own practices; but we do believe that results are better when we are allowed to do things the way we feel they should be done.

I find that a great deal of the things that I planned to say here have been said, apparently again and again, yesterday and this morning. Perhaps in your search for a consensus it would be worthwhile going through them just item by item.

I mentioned in an aside to Mr. Hickman here that from the testimony you have heard before it appears that he and his colleagues in the construction industry are responsible for all the problems and we designers get off scot free.

I am sorry that is not really the case. There are causes of structural failures that are attributable to the structural engineers.

Mr. GORE. Well, I wouldn't want to leave the impression that that is our feeling or conclusion. I think that the evidence has tended to indicate that one major avoidable cause of problems is in the nature of the relationship between the various professions involved in new construction projects.

The nature of the communication between them and the way responsibility to avoid errors is handled in the new organizational forum.

I would not adopt a conclusion that the construction company is always to blame, of course not. Nor would I feel the structural engineer is but there is an interface between the two where I think the problems can occur.

I am sorry to interrupt. Go ahead.

Mr. ARCHER. In thinking about what I would like to suggest to this committee, I think I bring to it a more cynical attitude than the other witnesses in that I have little confidence in persuasive techniques in the face of economic pressures here.

The committee has the legislative tool which I think is much more effective in the face of economic pressure than persuasion, attempting to get the professional societies, the educational institutes, the industry in general to be better is, unfortunately, best done through law.

Mr. GORE. Mr. Archer, let me ask you to clarify that last point that you were saying about legal remedies, you think they are necessary or are not necessary?

Mr. ARCHER. I think that they are the only answer.

Mr. GORE. OK, go ahead.

Mr. ARCHER. Having admitted that we structural engineers do make mistakes, I would like to itemize how we do it and how we can prevent future occurrences of it.

We do occasionally make mistakes in design, flatout mistakes.

We do, more frequently, inadequately or erroneously represent our designs in the drawings and specifications that the contractors have to work with.

These are the errors that we have direct control of. Beyond that, as mentioned in great detail there are nonconformances in the construction and in the materials furnished for construction which lead to failures.

To a very small extent, failures might be attributed to inadequate testing of new materials or innovative designs but I think that is so small that it doesn't merit the attention of the committee in view of the predominance of these other concerns.

And then far beyond the engineer's or the constructor's control is the type of thing that Mr. Crozier mentioned, that the user or the owner abuses the structure and uses it for loading conditions that were never contemplated in the design.

Why do these things happen is probably more of concern here. Why do improper designs get built? There is a list of reasons for that.

The first thing that an engineer should do is develop the design criteria. If, as happened to us recently, the architect fails to tell us that he is putting the library stacks on an upper floor rather than the ground floor, we haven't properly established the design criteria and when the stacks are put on the upper floor the floor will fail. It is not our fault but proper design criteria has not been established.

Sometimes the engineer fails to assign qualified engineers to perform the design and I would like to talk about that in more detail in a few minutes.

To continue with the list, a frequent cause of design errors getting into the construction phase is failure to provide independent checking of the design. Mr. Vosbeck mentioned that and I think it is extremely important.

It has been mentioned earlier that there is inadequate awareness of the relatively simple causes of the failures that have been investigated.

I say simple causes because in all of the notorious events that I have followed in the technical literature, the causes were quite simple and well within existing technology to have prevented.

The answer to that, aside from the publication of more information on the causes of these failures, would be the training of engineers specifically in the importance of connection details, the necessity to provide for expansion joints, these rather simple mundane things that lead to these failures.

There should be a course in the structural engineering curriculum addressing just these questions and emphasizing their importance.

A factor that concerns me very much in mistakes getting through is the delegation of preparation of detail drawings to material suppliers or subprofessional engineering detail shops.

Unfortunately, this has become such a widespread practice; and I am speaking of reinforcing bar detailing, structural steel detailing; that it is probably irreversible.

A remedy does exist in that, if these details must be prepared by some other organization, then the design engineer could be required to make a detailed review of those detail drawings.

Another thing concerns me, particularly when I look at our recruits each year—Burns & Roe engages in a recruiting program to bring in new graduates. We find that they are not trained in the use of the English language and so when they write specifications they come out not adequately conveying the intent of the design and we have many arguments with contractors about what we intended rather than what we said.

Those are the fortunate occasions when it comes to light. More often the contractor does what it says in the specifications and it isn't what was intended.

To go one step further from why these things happen, getting on into the implementation of the construction; I was pleased to hear all of the testimony favoring participation by the structural engineer in the ongoing process of construction.

I confirm along with the consensus that these days there is inadequate and sometimes no inspection by the design engineer of the construction.

A sub-item of this not having a representative of the structural engineer on the job is the situation wherein the contractor finds that there is a more efficient way of doing the job or a more efficient material to use and he proposes to make that substitution and presents a good argument for it, not only the economic argument but reasons why it should work. There is usually a long history in the design of a project that only the design engineer knows.

A substitution that may appear perfectly plausible to even a structural engineer on the staff of the owner, for instance, who is asked to agree with this, but he won't know that design history and therefore he will not be able to give the proper answer on those substitutions.

So I think it is extremely important that the design engineer be involved not only in continuous inspection of construction but in decisions on substitutions or changes to his design.

An aspect that the design engineer might help as far as Mr. Crozier's problem with misuse of the structure is that we could do a better job of documenting our designs. Preparing as-built drawings so that when change in the use of a structure is planned the proper information will be available to make a proper judgment as to whether, for example, Mr. Crozier's parking garage can support a stack of paper or not.

We don't do as good a job as we should in documenting our designs on the as-built condition of the project.

What can be done to correct these situations? I am impressed that the biggest problem is economic and that is behind my statement that persuasion is not going to change things. The law will change things.

The Government hasn't been helping the engineering profession in recent years in that the Government has been pressing the engi-

neering societies, in particular, to remove their restraints on their members from participating in competitive price bidding.

That has encouraged private industry to look more and more to competitive price for engineering services rather than qualifications of the engineer to do the particular type of structure that he has in mind.

It has a consequence of the engineer knowing that his proposal will be judged primarily on price. He must, of course, get that price down. He cannot risk cutting corners by doing an inept design job but somehow he must reduce the time required to do the job. Instead of designing all of the project why not write a specification that says the contractor will design and build part of the project? He can separate our pieces of the project that way, thus enabling himself to come out with a lower man-hour estimate for his participation in the project.

It is kind of cutting his own throat in that he is giving away work that he would be getting paid to do but if he doesn't give it away, he won't get the job in the first place because the owner is more and more selecting the engineer on the basis of how many man-hours does he say he can get this job done for.

The result of this delegation of design work is that it becomes the primary responsibility of the contractor that wins the bid to design and build some portion of the work.

He may have some structural engineers on his staff. He may delegate the work further to an engineering organization that he will select, probably on a competitive price basis. Either his subcontract engineer or his captive engineers, if you will, will be under enormous pressure to provide a marginally adequate design because every bit of savings he can make in design are multiplied geometrically by the savings in construction costs.

There could be a solution to this problem similar to my suggestion earlier that engineers should check details of reinforcing steel, structural steel. The engineer could be required to review and approve the design that he had sloughed off to a contractor.

However, our legal staff advises us to stay away from that. It is going to be a marginal design and the probability of failure is going to be greater. Once you look at his design you are in bed with him. You are part of the responsibility.

So we have written specifications that say that the contractor shall design and he shall not submit drawings until he has completed the construction. We do want the drawings for record purposes in the event of future changes but we don't want to even have it be suggested that we looked at them.

Mr. GORE. That is very interesting.

Mr. ARCHER. That is the advice of legal counsel. Don't get involved and don't give the appearance of being involved if you are not going to assume full responsibility for that design and do it yourself.

I don't know what the committee can do about the economic situation that forces these situations but perhaps through building code requirements that the engineer do certain things, the owners will be forced to let the engineer get paid for doing those things.

There is another area of legal activity concerning the licensing of engineers. It is my impression that the State boards who control licensing now could do a great deal more.

I would like to give Iowa credit for taking a very forward step in that in the last couple of years they have made continuing education a prerequisite for renewing professional licenses.

I don't think there is another State that does that. Iowa has started on a fairly low key basis. It is pretty easy to meet their requirements and I assume they will stiffen them up as they go along. I hope that other States follow suit.

Given the advanced state of the art of structural analysis these days, in our recruiting program I looked for people with master's degrees. I think that there is sufficient justification to make a 5-year curriculum or a master's degree a prerequisite for licensing of structural engineers these days. I know of no State where that is required.

Back to the continuing education and our concern that engineers are not generally aware of the causes of failures and the simple problems that lead to failures. The continuing education requirement, that should be a prerequisite to licensing or renewal of licenses could be specific in requiring a continuing education course in just this topic of failures and why they occur and how to prevent them.

I mentioned earlier that we were involved with the Nuclear Regulatory Commission's quality assurance requirements and I mentioned that I was somewhat skeptical as to how effective they were. I was earlier on pleased to hear you, Mr. Gore, endorse the idea that the engineer must provide the inspection during construction.

The Nuclear Regulatory Commission's requirements don't read quite that way. They require the contractor to police himself. They do provide that quality assurance personnel within the contractor's organization must report independently to top management of the contractor's organization. Presumably that gives them some degree of independence of the pressures of the schedule and costs.

I don't think it is very effective. Certainly it can't be as effective as the engineer who has not the responsibility to get the job done within the budget and the schedule at least as directly as the contractor does, and can function much more independently in monitoring the quality of the work.

However, there are other aspects of the Nuclear Regulatory requirements that would be helpful. I hesitate to mention NRC because it has a terrible reputation for being extremely expensive and causing serious delays. Our people who are involved with other than nuclear work shrink at the thought of having to apply quality assurance requirements similar to nuclear requirements.

However, in theory, they are good in that they require design checking. Mr. Vosbeck has mentioned that. I can emphasize it more. The design must be checked. We are all human. We can make mistakes. Where the engineer who is assigned to do the design does it and nobody looks at it, that shouldn't be, there should be a design check.

In Europe, I understand, that design check is done by the government.

I am not advocating creating a Federal bureaucracy to check every design of every public facility in the United States. We engineers in private practice can do it and we would be pleased to have the work of checking our colleagues' designs and have them check ours. At least speaking for Burns and Roe, we have no hesitancy to having another competent engineer review our design.

In doing it that way the only Government action required would be to write into law that such a design review must be made and then it would be simply a checkoff procedure that the construction permit would not be issued until a qualified independent design review had been completed.

Similarly, during construction, the Government involvement could be limited to not issuing a certificate of occupancy or whatever document is required until the design engineer himself had certified that he had inspected the construction and found it to be in conformance with his plans and specifications.

I don't agree that that is not possible to do. We do sign drawings prepared by a team of, in my case, 50 or 60 engineers. I feel that I can follow that through supervisors and direct supervision so that I can safely sign those drawings attesting that I have supervised this design and I am sure it is right.

Similarly, I feel that if I have control of the selection of the inspectors who will watch the myriad operations that are going on and if I have enough money in our contract to hire those engineers to inspect the work, then at the end of the job I will have no reluctance to sign a certificate that says this project was built in conformance with our drawings and specifications.

So, I don't know what the committee can do regarding the economic factors but that is a matter of emphasis. I would like to have the committee do what it can to bring professionalism back to professional engineering to deemphasize the selection of engineers by cost.

I think that will go a long way toward preventing failures and specifically I can see legal remedies to requiring design checks by an independent engineer and construction inspection by the design engineer.

With these steps I think we will have gone a long way to reduce the occurrence of structural failures.

I thank you for the opportunity to say so.

[The prepared statement of Mr. Archer follows:]

PREPARED STATEMENT OF JOHN C. ARCHER

Testimony of John C. Archer

The following opinions concerning the causes of structural failures are offered principally in outline form in difference to the Subcommittee's limited time and represent the witness' personal opinions.

I Causes of Structural Failures

1. Improper design
2. Inadequate/erronious representation of the design in drawings and specifications used for material procurement and construction.
3. Non-conforming materials.
4. Non-conforming construction.
5. Service loading in excess of loading considered in design.

II Reasons for the Causes of Structural Failures

1. Reasons why Improper Design occurs:
 - a) Failure to establish appropriate design criteria including:
 - 1) definition of service and environmental loading conditions applicable to the structure
 - 2) evaluation of site (foundation) conditions affecting the design
 - 3) selection of structural materials and material properties (strengths)
 - 4) selection of design methods.
 - b) Failure to assign qualified engineers to perform the design.
 - c) Failure to provide independent checking of the design.
2. Reasons why inadequate/erronious representation of the design in drawings and specifications used for material procurement and construction occurs:

- a) Inadequate education/training of engineers, particularly those entering the profession, in the importance of details as contributing causes of structural failures and in how to properly detail structures.
 - b) The delegation of preparation of detail drawings to material vendors or sub-professional "engineering" organizations.
 - c) In cases where detail drawings are prepared, as in b) above, by other than the Design Engineer, the absence of a thorough review or any review at all by the Design Engineer.
 - d) Inadequate education/training of engineers entering the profession in how to write coherently and unambiguously such that written specifications will accurately define what is required by the design.
3. Why non-conforming materials can be incorporated in the construction:
- a) Specification deficiency: material properties assumed in design not clearly required by the procurement specifications or required but without adequate testing/verification being called for.
 - b) Inadequate or no inspection and verification of properties of materials as delivered.
 - c) Substitution of materials without concurrence of the Design Engineer.
4. Why non-conforming construction can proceed to completion:
- a) Drawings and/or specifications inadequately conveying the intent of the design.
 - b) Inadequate or no inspection by the Design Engineer or a qualified representative.
 - c) Changes made in the field to facilitate construction without concurrence of the Design Engineer.

5. Why structures are exposed to service loading in excess of loading considered in design:
 - a) Inadequate documentation and/or document retention of the original design basis.
 - b) Inadequate or no preparation of "as-built" drawings and retention thereof.
 - c) A general lack of conformance with the posting of design loads (frequently required by building codes but rarely enforced) and a lack of understanding or attention to posted design loads by owners/users of the structure.

III Conditions underlying the reasons for the causes of structural failures:

1. Economic

In the present climate of price bidding for engineering services, fostered largely by the Federal Government, Engineers are no longer the Owner's agent, guiding and assisting him to ensure the completion of structures to optimally fulfill the function the owner intended but are now one more low bidder along with the contractors and material suppliers. As such it is essential to the engineering firm's economic survival that it submit "proposals" (read bids) on the basis of expending the minimum possible number of engineering manhours. Survival as an engineering firm can also depend on not being responsible for a structural design that fails. These two conflicting survival requirements encourage the sloughing off, onto material suppliers and contractors, design work that should be done by the Design Engineer. More and more we see bid specifications prepared for the owner by the Design Engineer which require the bidding contractors not "to construct in conformance with the Engineer's drawings" but "to design and construct a structure conforming to the Engineer's general arrangement drawings and the performance requirements of the specification".

Thus the design of structures is delegated to organizations where engineering is subordinate to the principal business and where the engineers are subject to inevitable pressure to produce marginally adequate structural designs in order to increase construction profit. In order not to be associated with such marginal designs, with their greater potential for structural failure, the Design Engineer is discouraged

by his legal advisors from reviewing the Contractor's design.

Requests for Proposals for Engineering Services often include "Construction Management" which at least implies construction inspection to ensure that the contractor's work conforms to drawings and specifications. The Engineering firm whose bid is lowest is likely to include a dollar allowance for minimum inspection and by the least qualified inspectors.

2. Management versus Professionalism

The American approach, only recently being mildly questioned in view of the success of foreign competition, that an intelligent individual well trained in management can manage any endeavor, included engineering, has fostered a climate within engineering organizations which discourages responsible professional performance by working engineers. Such management, with computerized progress reporting techniques, is predominately influenced by production of numbers of so-called "deliverables", drawings, specifications, etc. on schedule, without regard to content or quality. Personal advancement of engineers is thus dependent on production volume rather than technical excellence.

3. Legal

Regulation of the practice of engineering by the States through licensing of professional engineers could be much more effective in promoting professionalism than it generally is today. Advances in the state-of-the-art of structural analysis indicate that a State Board requirement of a 5 year curriculum, rather than the typical 4 year BS degree, could be justified as a prerequisite for licensing. State Boards could examine the curriculae for teaching specific to those areas found to be associated with structural failures before recertifying the engineering school. Continuing education is essential to the proper practice of structural engineering and should be a condition for periodic renewal of professional licenses.

Regulation of engineering and construction of public facilities by any level of government is generally, with of course, some exceptions, not as effective in providing assurance against structural failures as it could be. States have generally deferred to local authority or abdicated to OSHA. Local authority is generally inadequately staffed to be effective.

IV Recommendations

I hesitate to mention the Nuclear Regulatory Commission's requirements as an example of legal requirements to preclude structural failure, because they have the reputation within engineering and construction of grossly increasing costs. However, the greater cost of compliance with nuclear regulations, justified by the greater hazard, need not necessarily deter government from regulating public facilities in a similar manner to a lesser degree and cost appropriate to the lesser hazard. Many features of 10CFR50 are directly applicable to the causes and conditions conducive to structural failures described above and could be implemented without creating a large federal agency or any federal agency if the states were encouraged to legislate regulations which would be implemented by the engineering profession - if required by law; such as:

1. A major deterrent to design deficiencies is checking of the design. For public facilities, (some lower bound, say in capital cost, should probably be applied) an independent design review by a qualified engineering firm could be a legal requirement. The government agency's involvement could be limited to issuing a building permit only upon notification of a satisfactory design review by the independent engineer.
2. A building permit prerequisite could be submitted, by the owner, of a Quality Assurance program and a commitment therein to a specific program of materials and construction inspection by the Design Engineer or a qualified independent inspection organization. The government agency's involvement could be limited to issuing a certificate of occupancy only upon notification by the engineer or inspection agency that the construction was completed in conformance with the design.

Further regarding recommendations, it is obvious from my remarks under economic factors above that I would recommend that the government attempt to foster professionalism in engineering rather than, as I perceive it, to discourage selection of engineers on the basis of qualifications by forcing competitive price bidding for engineering services.

Mr. GORE. Thank you very much.

Our final witness is Mr. Key Hickman, chief estimator for the Volpe Construction Co.

Welcome, Mr. Hickman.

Mr. HICKMAN. Thank you. I appreciate being here. I am sure I have heard just about everything that was part of my testimony so I will try to keep my comments short so I will be available for more questions.

Mr. GORE. That will be fine.

Mr. HICKMAN. There is no quick fix to minimizing structural failures, because the construction process is broken down into so many complex facets that, in order to even approach the problem, I think we have to analyze the process as a whole from the beginning to the end of the process.

I think the reason behind structural failures can be found anywhere in this spectrum.

We live in the age of never-ending technological advancement and, when we admire works, for example, exhibited in the east wing of the National Gallery of Art, and notice the overhead space-framed skylight, or go to an athletic event at the Capital Centre and realize there isn't a single column supporting the center roof, we forget how, only a few years ago, these design techniques were not available.

I am sure, if we were to bring together the thousands of people that it took to build this building, for example, it would be hard to explain how such an undertaking could have been conceived, much less completed.

Planners are faced with budgetary restraints and sometimes totally unrealistic and unforgiving completion dates. Architects must continually perceive the wants of the public, in terms of forms and functions which change constantly, and structural engineers are barraged with new materials, methods, and design criteria. Finally, contractors are endlessly searching for new techniques to economically construct a facility or be faced with extinction if their competitors surpass them.

The concept of specialization in the professional disciplines of the industry has only been around for a short time. Today, we have specialists in every field imaginable. The only pitfall lies in the fact that the more you delegate individual responsibilities, the greater the chances for error.

Although the public generally assumes a structural failure occurs due to the incompetency of either the structural engineer or the builders, this is not the true picture of this very complex problem.

To illustrate this point, I offer you three examples.

First, I have seen a case where a failure occurred when an architect located in the Northeast was given a contract to design a job in Florida. He also chose to assign the structural design to an engineer not familiar with the area where the facility was to be built.

The building was completed and, in time, a tropical storm dumped 8 inches of water on the roof in a matter of hours. The roof drains were not sufficient to shed the volume and weight of such a load, and the roof collapsed.

Was this the fault of the engineer or should the architect have hired an engineer familiar with Florida's torrential rains? Should the contractor have known that the drains were insufficient?

Mr. Crozier has already given my second example; namely, loading a building for more than what it was designed. And, I have given an example of how a contractor gets in a situation of being in such a rush to complete a building.

Last, a contractor was to complete a facility on a specific date or suffer liquidated damages. Halfway through completing the structural concrete skeleton, he realized that he would be faced with liquidation damages unless he poured concrete at a much faster rate. The local county building jurisdiction required only that test cylinders be taken on concrete to assure its strength.

Mr. GORE. We wanted to make you all feel at home during the hearing, so we thought we would have some construction noise.

Mr. HICKMAN. Oh, it sounds great. I hope it is on time and in budget.

The contractor decided to make his own test cylinders, rather than hire an independent lab. He had not experienced, up to this point, any problems with the concrete satisfying its design strength in 7 days, but now he had to strip forms in 4 days instead of 7 to make up time.

The concrete ready-mix company supplying the job inadvertently sent the wrong mix and, because the contractor was in such a rush, he neglected to make concrete test cylinders. He stripped the forms in 4 days, without knowing if the concrete has reached its proper strength, and the building collapsed.

In this case, the building contractor was definitely at fault, however. But, had the county required an independent testing agency to perform tests and provide written notification to the contractor as to the strength of the concrete before he could strip form work, would a collapse have occurred?

Had the owner not imposed on the contractor an unrealistic time to complete the structure, would the same thing have happened?

You may ask, is there an answer to minimizing structural failures? I believe there is; namely, setting forth requirements for funding and enforcement of good quality control programs.

Mr. GORE. And, eliminating those things which frustrate good quality control?

Mr. HICKMAN. That is correct. As contractors, we see quality control procedures described in specification every day, but rarely are they enforced.

I think quality control should be strictly enforced if it is to be effective. Consistency in enforcement is very important to a contractor because, if there is going to be additional costs or time involved, he must be aware of the restrictions imposed in order to include these additional costs.

I think, as Mr. Archer has stated, that the problem of monetary restraint continually hampers the contractors, engineers, and the architects from implementing strong quality control programs.

It is hard for an engineer, when he is in a competitive situation, as it is for the contractor to include costs that may be necessary to insure quality control when his competition will leave out these additional costs just to be low bidder.

Therefore, I think the answer to alleviating the problems we are having, whether it be on the part of a planners, architects, engineers, builders, or workmen in the field; is to have a separate, unbiased entity making quality control checks, and possibly entertain setting up a standardized quality control program nationwide.

I find, in bidding work up and down the east coast, that each State or jurisdiction has its own requirements.

For example, in Florida a general contractor has to pass a test to be licensed to conduct business in that State.

And I think a testing program and licensing of contractors would be an excellent step in order to assure overall quality control program. Problem areas of structural failures could be incorporated in this testing program.

I have cited that the cost of quality control shouldn't be the biggest roadblock to minimizing structural failures. If you look at a \$10 million building I would estimate the cost of a quality control program would probably be less than 1 percent of the total cost, which is nothing when you compare it to the amount of lives and property that could be lost if a structural failure occurred.

I think another problem is that the contractor in most cases is not brought into the planning stage of the building process. He therefore is unaware of specific structural conditions which might warrant additional consideration, cost and time to complete a particular operation.

Generally speaking, 90 percent of a contractor's work, unless he specializes in negotiated work, is bid on a competitive basis.

So, therefore, he has to be able to shave every possible corner in order to be competitive. If quality control is not dictated and definitely defined, how can a contractor be expected to include it in his proposal.

I am ready for questions.

[The prepared statement of Mr. Hickman follows:]

August 1, 1982

Mr. Albert Gore, Jr.
Chairman
Subcommittee on Investigations and Oversight

Dear Mr. Gore:

I appreciate your Committee's invitation to discuss the underlying causes behind structural failures which have recently occurred in public facilities.

There is no quick fix when it comes to minimizing structural failures. The construction process is broken down into so many complex facets that in order to even approach the problem we must analyze it from the beginning to the end; from conceiving the need for a new facility to maintaining it on a day to day basis once construction is complete. The reasons behind the failures can be found anywhere along this spectrum.

We live in the age of never ending technological advancement. When we admire the works exhibited in the East Wing of the National Gallery of Art and notice the overhead space framed skylight or go to an athletic event at The Capitol Centre and realize there isn't a single column supporting the center roof, we forget how only a few years ago these structural design techniques were not available for our comfort and enjoyment. I'm sure if we were able to bring together all of the thousands of people who contributed to the construction of this building, it would be hard for us to explain how such an undertaking could have been conceived, much less completed.

Planners are faced with budgetary restraints and sometimes totally unrealistic and unforgiving completion dates. Architects must continually perceive the wants of the public in terms of forms and functions which change constantly, and structural engineers are barraged with new materials, methods, and design

criteria. Finally, contractors are endlessly searching for new techniques to economically construct a facility or be faced with extension if their competitors surpass them.

The concept of specialization in the professional disciplines of the industry has only been around for a short time. Today we have specialists in every field imaginable. The only pitfall lies in the fact that the more you delegate individual responsibilities, the greater the chances for error.

Although the Public generally assumes a structural failure occurs due to the incompetency of either the structural engineer or the builders, this is not the true picture of this very complex problem. To illustrate this point, I offer you three examples. (1) I've seen a case where a failure occurred when an architect located in the Northeast was given a contract to design a job in Florida. He also chose to assign the structural design to an engineer not familiar with the area where the facility was to be built. The building was completed and in time a tropical storm dumped 8" of water on the roof in a matter of hours. The roof drains were not sufficient to shed the volume and weight of such a load, and the roof collapsed. Was this the fault of the engineer or should the architect have hired an engineer familiar with Florida's torrential rains? Should the contractor have known that the drains were insufficient? (2) A Government agency had to relocate because its lease had expired. The new space to be used to store records was only half the size of the old. The records were stacked to the ceiling and completely filled the new room -- the floor started sagging under the load, and if it had gone unnoticed by the Building Manager, it surely would have collapsed. (3) A contractor was to complete a facility on a specific date or suffer liquidated damages. Half way through

completing the structural concrete skeleton he realized that he would be faced with liquidation damages unless he poured concrete at a much faster rate. The local county building jurisdiction required only that test cylinders be taken on concrete to assure its strength. The contractor decided to make his own test cylinders rather than hire an independent lab. He had not experienced, up to this point, any problems with the concrete satisfying its design strength in 7 days, but now he had to strip forms in 4 days instead of 7 to make up time. The concrete ready-mix company supplying the job inadvertently sent the wrong mix, and because the contractor was in such a rush, he forgot to make concrete test cylinders. He stripped the forms in 4 days and the building collapsed. In this case, the building contractor was definitely at fault; however, had the county required an independent testing agency to perform tests and provide written notification to the contractor as to the strength of the concrete before he could strip formwork, would a collapse have occurred? Had the owner not given the contractor an unrealistic time to complete the structure, would the same thing have happened?

Is there an answer to minimizing structural failures? Yes, the answer, I believe, is funding and enforcement of a good quality control program.

Quality Control should not be just a phrase that is described in the specifications. It must be strictly enforced if it is to be effective. Consistency in enforcement must be the rule, not the exception.

The sadest part of the present system is that for the lack of funds, quality control programs are one of the first requirements to be scrapped. When architects and engineers compete, they cannot include all the necessary costs for quality control unless it is stipulated as a specific requirement

in the planning stage. Another problem with this scenario is that quite often when the architect or engineer is charged with this responsibility, it may lead to conflicts of interest during the job's progress. A separate, unbiased entity is therefore necessary.

In order to implement a standardized national quality control program, I would suggest the following: The first step would be to establish a working partnership between planners, architects, engineers, and contractors; The second step would be to use the structural failures we have experienced to point out the areas which need improvement; and third, implement standard quality control requirements that could be enforced by an unbiased, independent concern.

The cost could not be the biggest roadblock that stands in the way of such a program. I think if we look at the over-all picture, we will find that the total dollars are miniscule compared to the loss of lives, property, and services which structural failures cause. If I would have to estimate, let's say, on a 10 million dollar project, the cost of implementing a strong quality control program would probably be less than 1% of the total construction cost.

If the public mandates we be given this challenge, I see no reason why we couldn't address the problem effectively and reduce structural failures nationwide.

Thank You,

A. Key Hickman, Chief Estimator
Volpe Construction Company
Washington, D.C.

Mr. GORE. Thank you very much. I think this has been a fascinating panel.

Mr. Crozier, in your experience, are quality control procedures required by contract and if so, does the contract describe procedures to be followed?

How does it work in your experience?

Mr. CROZIER. In my experience the quality control planners are set out in the specifications and then I have never found any particular concern with testing. It has not been a problem for us.

It seems that what we have asked for has either been done by the contractor or by independent agencies. In terms of, for instance, window checks and building frames and all that.

I am sensitive to this point that I have heard from the three people this morning about quality control.

I am going to have to go back and study up on it a little bit more. It is an area that I have just not been as sensitive to as I should.

Mr. GORE. Well, maybe it is because you do it and don't necessarily use that label or just don't pay close attention.

Mr. CROZIER. Or maybe we don't do it and we ought to look at it. But the words came across this morning that made me take some notes to go back and look at it a little more.

Mr. GORE. Well, that is great.

Mr. Hickman said in his prepared text that when there is a lack of funds, "quality control programs are one of the first requirements to be scrapped," and that is consistent with the testimony we have had throughout these 2 days of hearings.

Mr. CROZIER. I would have to disassociate myself from those remarks.

Mr. GORE. I am not saying that that is the way you operate.

Mr. CROZIER. I don't even think it works that way very much because I believe that you are talking about such relative peanuts in terms of those matters that it is not where people are at in terms of cost-cutting.

If you have got a \$10 million building as Mr. Hickman talked about and it is over budget, the pennies that you can cut out of quality control—

Mr. GORE. He didn't say it was a rational decision. He just said that it was made.

Mr. CROZIER. All right.

Mr. GORE. Other engineers, builders, and architects have said that.

Mr. CROZIER. We look for big ticket items when we are over budget.

Mr. GORE. Mr. Hickman.

Mr. HICKMAN. I realize what Mr. Crozier is saying because he is involved in a certain area, I would think, office buildings which there is very little need for rigorous quality control, because it is a repetitive situation.

They have been building buildings here out of concrete frames for 40 years.

Mr. GORE. I see.

Mr. HICKMAN. I think each construction project has its own structural personality. Therefore, the scope and magnitude of a

quality control program should be based on specific needs on a project-by-project basis. I don't see the need for such a rigorous program as stadium construction being necessary for lets say typical office building construction.

The techniques for constructing an office building are standardized and have been proven over the years, as opposed to todays stadiums that have design assumption based on the end product not necessarily meshing with the least expensive construction system that could be utilized.

Mr. GORE. Or novel techniques like the long skywalk in the Hyatt, for example, something that is not an everyday occurrence when you are putting up office buildings that are familiar.

Mr. HICKMAN. I think any architect, engineer, planner or owner knows the difference between a typical situation and a special condition which needs to be eyed closer than typical standard conditions which have a safety track record.

Mr. GORE. Yes, Mr. Vosbeck?

Mr. VOSBECK. There is another aspect of quality control. I think what has been talked about just recently here has been quality control in the field. There is also quality control in the office, in the designer's office.

I find that there is practically no requirement with any owner or Federal agency or State or local jurisdiction that requires of their designers a thorough quality control system in their contract.

And it seems to me, and I think Mr. Archer agreed with me in that, that we really have got to somehow get into the design professionals scheme of doing things, more quality control checking and reviewing during the design stages.

Mr. GORE. Yes. Have you found that the use of construction managers puts a great deal of pressure on architects and engineers to rush the design and to eliminate some quality control routines?

Mr. VOSBECK. To rush the design, yes, because that theoretically, although the word construction manager means different things to different people these days, but I think in the typical sense when the construction manager is involved, he is involved to expedite, to overlap phases, to speed up the process.

When that happens or when there is a construction manager, oftentimes it is also assumed that the construction manager is going to do some of the reviewing and checking and quality control.

And I think the role, then, of the architect changes or tends to change in that we rely or we tend to rely then on someone else to do what we would often do under a more traditional procedure.

Mr. GORE. Mr. Archer, you gave a very vivid example of what I would refer to as legal advice to put blinders on when an engineer is trying to cut costs to submit a low bid and decides to eliminate some of the design work and affix responsibility for that design work on the construction company.

Your lawyers have advised you to actually write into the contract the requirement that the construction company not show you the design until the thing has already been built. That is really a vivid illustration.

Mr. ARCHER. I could say a little more about what happens next.

Mr. GORE. Sure, go ahead.

Mr. ARCHER. Within the last month we had occasion to pull those drawings out of the file because we wanted to support a pipe that we were designing off a structure that was specified to be designed by the contractor.

In order to support the pipe we had to look at his structure. When we looked at it it looked inadequate. And when we looked further we found that this structure which was a silo-type structure to retain ash on a coal-fired powerplant, and it was elevated, we found that the contractor's design was very adequate for support of the steel tank itself but it did not take into consideration the contents.

Mr. GORE. It was OK for an empty steel tank but not for a full steel tank.

Mr. ARCHER. Yes.

Mr. GORE. That is interesting.

Well, I think that is a pretty clear example of what I referred to earlier of responsibility being thrown around like a hot potato and while the potato is in midair some serious mistakes are likely to be made.

Do you think that investigations by the National Bureau of Standards of major structural failures would be a good idea?

Mr. ARCHER. I am not impressed that the investigation of structural failures will do a great deal to preventing future structural failures.

I say that because, as in the case of the Hyatt Hotel walkway failure, the NBS report was published—incidentally, it wasn't all the lack of communication between designer and the constructor—there was a subfinding that the original design was inadequate—we know these things and we know how to design structures that won't fail.

What we need to do is to require, I would like to say, the owners to spend the money with the engineers to do these things that I have talked about, design verification by a qualified independent engineer and spending money to pay the engineer to have inspectors on the job.

These are the things that address the problem directly.

Mr. GORE. Yes, but if that can be identified as the major contributing cause to a structural failure, it would enhance the tendency to do it differently in the future, it seems to me.

Mr. ARCHER. The future one, if it is done with the same restraints on checking of design and inspection of construction, will fail for a different reason.

Mr. GORE. Or it might not. Hopefully, it wouldn't.

Mr. Vosbeck?

Mr. VOSBECK. Well, I don't totally agree with Mr. Archer. I think that the more information that is available to us, the better. Then it is up to us to use it, of course, and we have got to make sure that professional societies and associations like AIA and ACEC and so on encourage their members to use it and have the appropriate dissemination of information, seminars and so on.

Whether, and you specifically asked about NBS, whether NBS is the right group or another group, I don't know. But it seems to me that something can be gained from having more information available to us.

Mr. GORE. Mr. Crozier?

Mr. CROZIER. If I don't say something here, I am going to be thrown out of the developer fraternity. Mr. Archer comes across to me as a very intelligent, sensitive engineer, one that I would like to work with, but it is like raking his fingernails across the blackboard when he tells me that after I hire him I can't go ahead with the building until I hire somebody else to check his work.

Why would I want to hire you in the first place, Mr. Archer, under those circumstances? I don't mean to direct my comments to him but let me just direct them to the panel.

If you said to us—and not only do we have to pay two people to get that one job done and, Mr. Vosbeck, I can talk to you about this one as well, now we are also prohibited from getting a building permit until the second guy gets the work, and I think that is a lot of baloney.

I don't see any necessity for that. You hire yourself out as a professional engineer. If I hire a lawyer I don't have to run all over-time. Why can't you do the work?

Mr. Vosbeck says the owner doesn't want to pay for quality control. When we signed you in the first place we thought you were getting quality control. If you are not giving it to me you ought to cut my fee.

Mr. VOSBECK. It was cut already.

Mr. GORE. Wait a minute, you already cut his fee.

Mr. CROZIER. We are going to do it again now.

Mr. GORE. Now we are getting a little action. Now we are getting to the bottom line here. You don't want to pay for extra procedures to check on something that should have been done right the first time.

Mr. CROZIER. That is right. Plus the fact that when Mr. Vosbeck says, well, we would like to work in the field, and then he says as an aside and a very charming aside, well, our drawings are not always perfect. I agree with him. They are not. We want them to be perfect.

What we are saying a lot of times is we don't want you to go to the field to correct your drawings. We want them corrected before they get into Mr. Hickman's hands.

Mr. VOSBECK. That is quality control you have to pay for then.

Mr. CROZIER. We don't want you to go in the field making separate deals with the contractor saying I will cover up this and you cover up this for me.

Mr. GORE. I know that all three of you fellow panelists would like to respond but if I may make a comment here, it seems to me after sitting through two days of these hearings that a good system must recognize the inevitability of some mistakes being made in the translation of a design into a building. And a good system would include and mandate a quality control check to make certain that avoidable mistakes are eliminated during the process.

And I don't think it is fair to require that architects and structural engineers be perfect in their work to the extent that no checking is necessary when a construction company takes their design and puts the building up.

Now, that is my own tentative conclusion but let me give you a chance to respond, Mr. Crozier.

Mr. CROZIER. Well, I think that if you tell the architect that those drawings better be right before they get into the contractor's hands you are going to get a 90 percent job. If you say to him, hey, do the best job you can, you are going to get an 80 percent job.

The higher your standards are and what you demand of the architect, first off, he likes it better anyway. The second is it reduces field problems.

So by slopping over and saying, well, you didn't catch it here, the checker will catch it or you can catch it in the field, I think that is bad. I think that takes the plans and specifications and makes them a mockery of what they really should be.

What they ought to be is the best possible set of drawings and specifications that can go into Hickman's hands and you don't want to let him off the hook.

Mr. GORE. And, you don't want to pay him to check it?

Mr. CROZIER. When you are working with the contract form and you say you got enough money, they always say yes. It is only after the problem that somebody says, gee, you should have paid me more money.

Mr. GORE. They either say yes, I got enough money or they say, no, and you get somebody else who says it is enough money.

Mr. CROZIER. We don't select anybody by competitive bid, so we don't understand that situation.

Mr. GORE. All right. I think again it is important to note that you are dealing with concrete structures low in height, and your testimony is excellent. I think it should be viewed against that background but, again, I really think that we are right at the heart of the matter right here. I think this is really the heart of the matter.

Mr. Archer, do you want to comment?

Mr. ARCHER. Yes. In case Mr. Crozier is serious about hiring us, I would like to reassure him that our standard procedures require a peer check of every design. That is a check by an engineer as well qualified as the engineer who did it originally, or better.

However, we are faced with a competitive situation where we are competing with engineers who don't do that and that process, the internal checking process that we feel is absolutely essential and we refuse to give up, has lost us jobs because it costs us 10 percent more of the owner's time and they won't pay when they are inviting bids on a competitive basis for engineering services.

Mr. GORE. Mr. Hickman, you wanted to comment?

Mr. HICKMAN. Yes. I think in the majority of cases an outstanding firm such as Mr. Crozier's is the exception to the rule.

The fact is that you have a lot of people involved in the planning stage that don't even know what guidelines should be included in the contract documents for quality control.

You have people putting a time restraint on building completion dates without any contractor input whatsoever.

If the contractor is faced with getting a job done in a specific amount of time, and that time is unrealistic to begin with, he may be faced with damages. His course is set, therefore, in attempting to get the project up as quick as possible and in many cases making changes in order to meet an unrealistic time schedule.

I think there is a lack of contractor input in the whole system of competitive bidding. It isn't the developer who negotiates with a contractor from the beginning stages (starting with three schematic drawings evolving into 500 drawings, as-built sets). That is what is involved that should be addressed.

When you are competing as opposed to negotiating directly with an owner, it is a reverse situation. Your hands are tied in a lot of ways, as compared to being involved from the conception of a project and directly conversing with the engineers involved.

Mr. GORE. Mr. Vosbeck, did you want to comment?

Mr. VOSBECK. Well, just briefly. When a developer comes to an architect or engineer and is interested in considering you for professional services and they want a price and they are going to two or three firms and looking for that price, and the developer says, of course, we want your drawings to be perfect, as Jim said, there will be one firm that thinks that means a very thorough quality control check and there will be others who will take the gamble and say, I am good, I know I can do a good job, I am not going to go through that check.

And that is where, as you said, the heart of the problem is. That is where I think Jim and I differ, and I think that there can be some sort of a requirement or regulation or code response to that situation so that everybody is on an equal basis as far as the quality control is concerned.

Mr. GORE. Well, I think we have learned a lot in these hearings. I think they have been unusually productive in describing the nature of the problem, which is apparently common to many of the major structural failures that have been so troubling to many in this country and we will have a report with a series of recommendations.

As I indicated yesterday, I intend to explore legislation to clarify the role of the National Bureau of Standards and the repository for information about major structural failures.

It is entirely likely that the subcommittee will have recommendations as to the uniform code and as to actions that might be taken by the professional societies and the other participants in this whole business.

But, I would like to close by thanking the members of this panel, particularly. I think it has been very, very interesting. Other witnesses have also helped us during the 2-day hearing, and I would like to thank the staff for excellent work in preparation for this hearing as well.

And with that, thank you, gentlemen.

The hearing will stand adjourned.

[Whereupon, at 1:15 p.m., the subcommittee was adjourned.]